# Real-Time Water Quality Deployment Report

## Vale Nickel Project

## Long Harbour

## Newfoundland and Labrador

## Annual Report 2010

Newfoundland Labrador

Government of Newfoundland & Labrador
Department of Environment and Conservation
Water Resources Management Division
St. John’s, NL, A1B 4J6 Canada

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## Acknowledgements

Successful real-time water quality monitoring in Long Harbour has only been achieved through the cooperation of Vale and the Department of Environment and Conservation (DOEC) under the guidance of many key individuals including, but not limited to, Brenda Brown (Environmental Superintendent – Vale), Bob Picco (Manager, Surface Water – DOEC) and Renée Paterson (Real-Time Project Coordinator – DOEC).

In planning monthly maintenance trips to Long Harbour, special consideration must be made regarding current conditions and operations at such a large-scale construction site. Nancy Whittle (Environmental Coordinator – Vale) has been invaluable for her advice and guidance to working on site.

Conflicting schedules arise from the management of many tasks and projects. Dwayne Ackerman (Water Survey of Canada) is thanked for his patience with changing schedules and his assistance in supporting communications and datalogging activities onsite in Long Harbour.

Finally, DOEC staff Keith Abbott, Tara Clinton, Shibly Rahman and Ryan Pugh are thanked for their hard work and assistance in regular maintenance, calibration and report writing.

# Introduction

## Background

The institution of continuous, near real-time water quality monitoring in Long Harbour, Newfoundland and Labrador began in 2006, prior to construction of the commercial nickel processing facility by Vale. Three years later, another two water quality stations were commissioned to provide a clear picture of water quality throughout the Rattling Brook river system. Currently, these three stations provide hourly updates on water quality and hydrometric parameters: temperature, pH, specific conductivity, dissolved oxygen, turbidity and flow/stage level.

**Figure 1: Rattling Brook Water Quality Network**

Shown in Figure 1, the network comprises of three stations (green triangles). Big Pond station is situated in the upper reaches of the Rattling Brook river system and provides a background picture of water quality without impact by construction efforts. As water progresses through the river system, Bridge station (the oldest in the network) is reached, followed by Discharge station.

Major earthworks in the area began in June 2009 and presented frequent problems with turbidity due to soil instability and heavy precipitation. The amount of unsuitable material such as bog and rock that required removal was underestimated and resulted in an insufficient ability to adequately settle out silt draining from the unsuitable materials (USM) storage sites. As construction progressed from heavy earthworks to the construction of infrastructure, settling capabilities have increased and silt screen placement has led to a reduction in elevated turbidity levels within the river system.

For more details, please see monthly reports.

## Site Specific Guideline Development and Alert Threshold Determination

The Department of Environment and Conservation has also instituted a system to automatically alert staff to turbidity levels above a predetermined threshold. These alerts are forwarded on to Vale staff who collect grab samples from Rattling Brook to assess the actual level of total suspended solids (TSS). Since pollution control measures in Newfoundland and Labrador present limitations for TSS rather than turbidity, there is a significant effort to model TSS based on turbidity with the goal of estimating TSS in real-time. Through this project, the Department has been able to lower the automated turbidity alert levels as Vale concurrently reduced the siltation impact on the river. Currently, the alert thresholds are set at 75 NTU at Bridge and 40 NTU at Discharge station.

Guidelines posted by the Canadian Council of Ministers of the Environment (CCME) posts national guidelines for the Protection of Aquatic Life in fresh water bodies. In the past, the CCME guidelines of 6.5 – 9.0 for pH was reported in monthly and annual reports. Such a range in values resulted in frequent exceedences (in many cases, almost an entire month's worth of data). The root of this is related to the national scope of the CCME guidelines and unique geochemical characteristics present in much of Newfoundland and Labrador. The result is naturally acidic waters throughout much of the province. To avoid the unintended implication that pH in Ratting Brook is being negatively impact by development, site specific guidelines (SSGs) for pH were developed. Using the background concentration methodology as outlined by the CCME, $5^{th}$ and $95^{th}$ percentiles were found for pH values in this river system, and a range of 5.67 – 6.56 pH units was derived.

### Hurricane Igor

On September 21st, 2010 Hurricane Igor – interacting with a stationary low-pressure system – caused extreme damage in eastern Newfoundland. Classified as a 50 – 100 year storm, the effects were devastating on infrastructure and homes in the region. The effects, however, were also felt in the environment regarding fallen trees and stream realignment from the > 200 mm of precipitation in some areas. Incredible volumes of water washing through rivers tore shrubs, trees and grasses from riverbanks resulting in significant erosion and instability. Turbidity spikes have been more common in many rivers, including Rattling Brook, since the storm and will likely continue until altered stream banks are recolonized by grasses and other stabilizing vegetation.

## Maintenance and Calibration

Maintenance and calibration trips are made to Long Harbour on a monthly basis to ensure each station is functioning optimally. A maintenance trip is composed of two days where on Day One the water quality instrument from each site is removed from the river and then serviced (cleaned and calibrated) in the Environment and Conservation laboratory in St. John's. On Day Two, the freshly cleaned and calibrated sonde is returned to the water body. The following tables outline the deployment periods for each station throughout 2010.

**Table 1: Maintenance and Calibration Outings for Rattling Brook Big Pond Station, 2010**

| Installation Date | Removal Date | Duration of Deployment (Days) | Remarks |
|---|---|---|---|
| 2009-12-16 | 2010-02-01 | 45 | Temporarily removed due to ice cover. |
| 2010-03-31 | 2010-05-04 | 34 | |
| 2010-05-05 | 2010-06-10 | 35 | |
| 2010-06-11 | 2010-07-15 | 34 | |
| 2010-07-16 | 2010-08-12 | 26 | |
| 2010-08-13 | 2010-09-15 | 32 | |
| 2010-09-16 | 2010-10-13 | 27 | |
| 2010-10-14 | 2010-11-17 | 33 | |
| 2010-11-18 | 2010-12-16 | 28 | |
| 2010-12-16 | 2011-01-20 | 34 | |

**Table 2: Maintenance and Calibration Outings for Rattling Brook below Bridge Station, 2010**

| Installation Date | Removal Date | Duration of Deployment (Days) | Remarks |
|---|---|---|---|
| 2009-12-16 | 2010-02-01 | 45 | |
| 2010-02-02 | 2010-03-02 | 30 | |
| 2010-03-31 | 2010-05-04 | 34 | |
| 2010-05-05 | 2010-06-10 | 35 | |
| 2010-06-11 | 2010-07-15 | 35 | |
| 2010-07-16 | 2010-07-29 | | Emergency replacement of S/N 44604 with S/N 43679 due to turbidity wiper problem. |

| Installation Date | Removal Date | Duration of Deployment (Days) | Remarks |
|---|---|---|---|
| 2010-07-29 | 2010-08-12 | | |
| 2010-08-13 | 2010-09-15 | 32 | |
| 2010-09-15 | 2010-10-13 | 28 | S/N 43679 switched with S/N 44604 following the repair of a turbidity probe. |
| 2010-10-14 | 2010-11-17 | 33 | |
| 2010-11-18 | 2010-12-16 | 28 | |
| 2010-12-17 | 2011-01-20 | 33 | |

**Table 3: Maintenance and Calibration Outings for Rattling Brook below Plant Discharge, 2010**

| Installation Date | Removal Date | Duration of Deployment (Days) | Remarks |
|---|---|---|---|
| 12/16/2009 | 02/01/2010 | 45 | |
| 02/02/2010 | 03/02/2010 | 30 | |
| 03/03/2010 | 03/30/2010 | 27 | |
| 03/31/2010 | 05/04/2010 | 34 | |
| 05/05/2010 | 06/10/2010 | 35 | |
| 06/11/2010 | 07/15/2010 | 34 | |
| 07/16/2010 | 08/12/2010 | 26 | |
| 08/13/2010 | 09/15/2010 | 32 | |
| 09/16/2010 | 10/13/2010 | 27 | |
| 10/14/2010 | 11/17/2010 | 33 | |
| 11/18/2010 | 12/16/2010 | 28 | |
| 12/16/2010 | 01/20/2011 | 34 | |

# Results and Discussion

## Parameters by Year

The following graphs and discussions detail major water quality parameters for each station year by year. This perspective gives a glimpse at potential long term changes in water quality. For Rattling Brook Big Pond and below Plant Discharge Stations, this represents approximately 16 months (October 2009 – December 2010) whereas Bridge station represents approximately 36 months (January 2008 – December 2010).

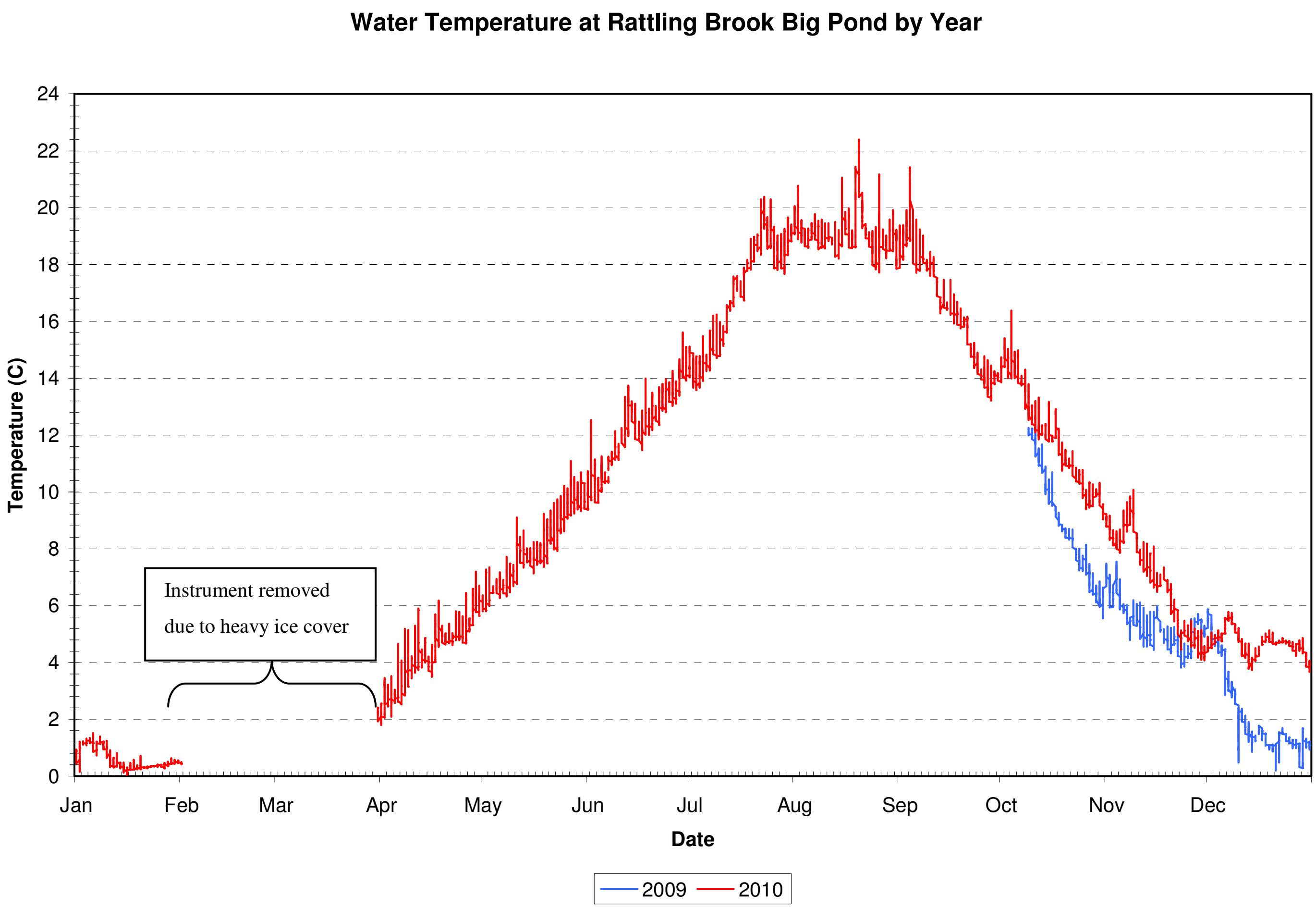
### Rattling Brook Big Pond

Commissioned in September 2009, this station is an upgrade to a previously deployed hydrometric station managed solely by the Water Survey of Canada. Since this station is at the top of the Rattling Brook watershed, the data recorded represents background values – all construction to this point has been downstream.

<u>Water Temperature</u>

In 2010, water temperature in Big Pond reached a plateau in mid-July until beginning to cool in early September. The highest recorded temperature was found to be 22.4$^{o}$C in mid-August and a median annual temperature value of 9.66°C was found (90% CI: 9.49 – 9.84). For the short overlap in available data for 2009 and 2010, water temperature was higher in 2009.

**Figure 2: Water Temperature at Rattling Brook Big Pond, 2009 – 2010**

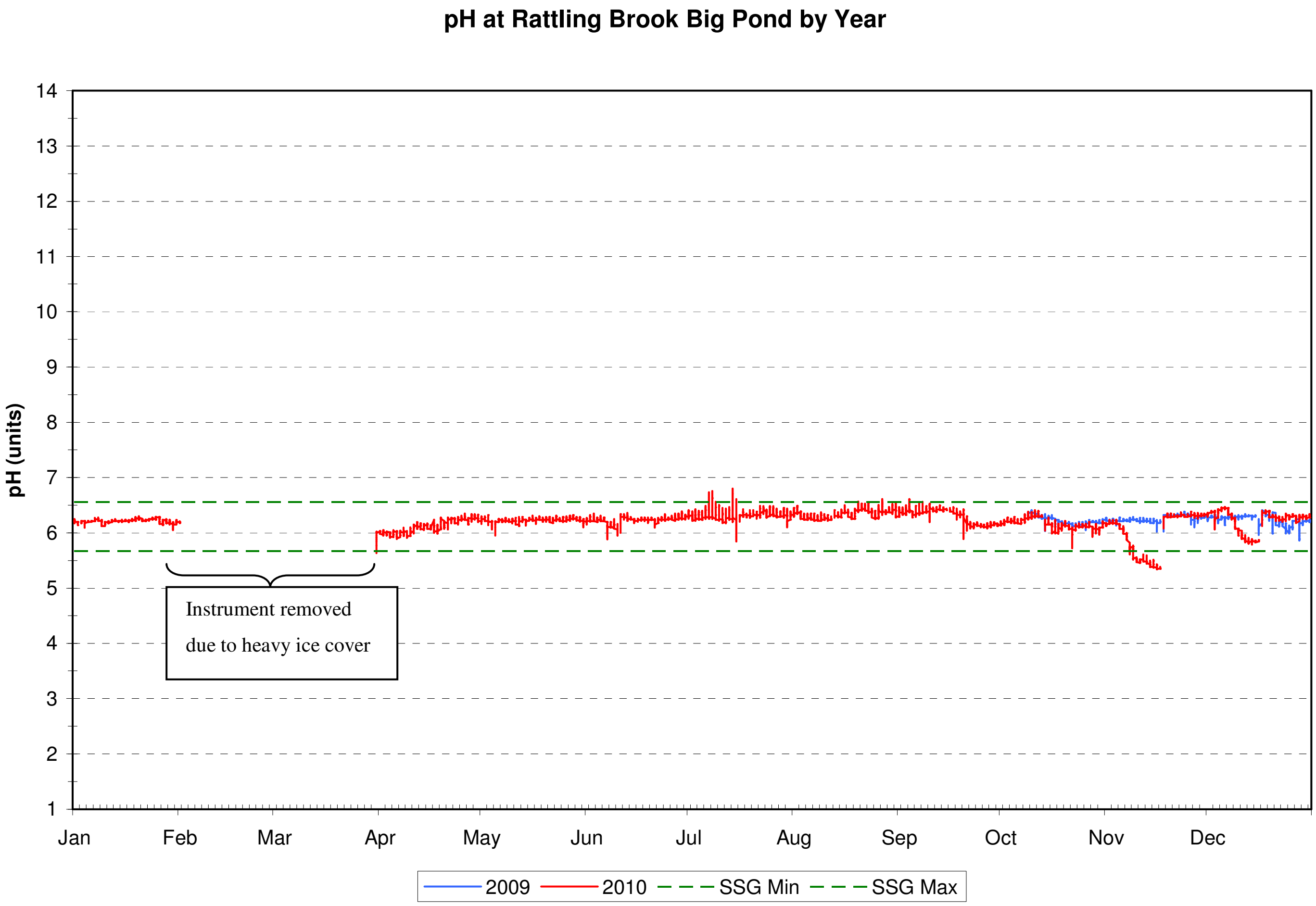



<u>pH</u>

Stable pH values are characteristic of Big Pond station. Values were recorded from 5.34 to 6.8 in 2010 with a median value of 6.25 (90% CI: 6.25 – 6.25)[1]. This median value fits well within the SSGs of 5.67 – 6.56 developed for the Rattling Brook system. Comparison between 2009 and 2010 shows a close overlap of both years.

[1] The tight confidence interval is due to the minimal variation in values seen at Rattling Brook Big Pond.

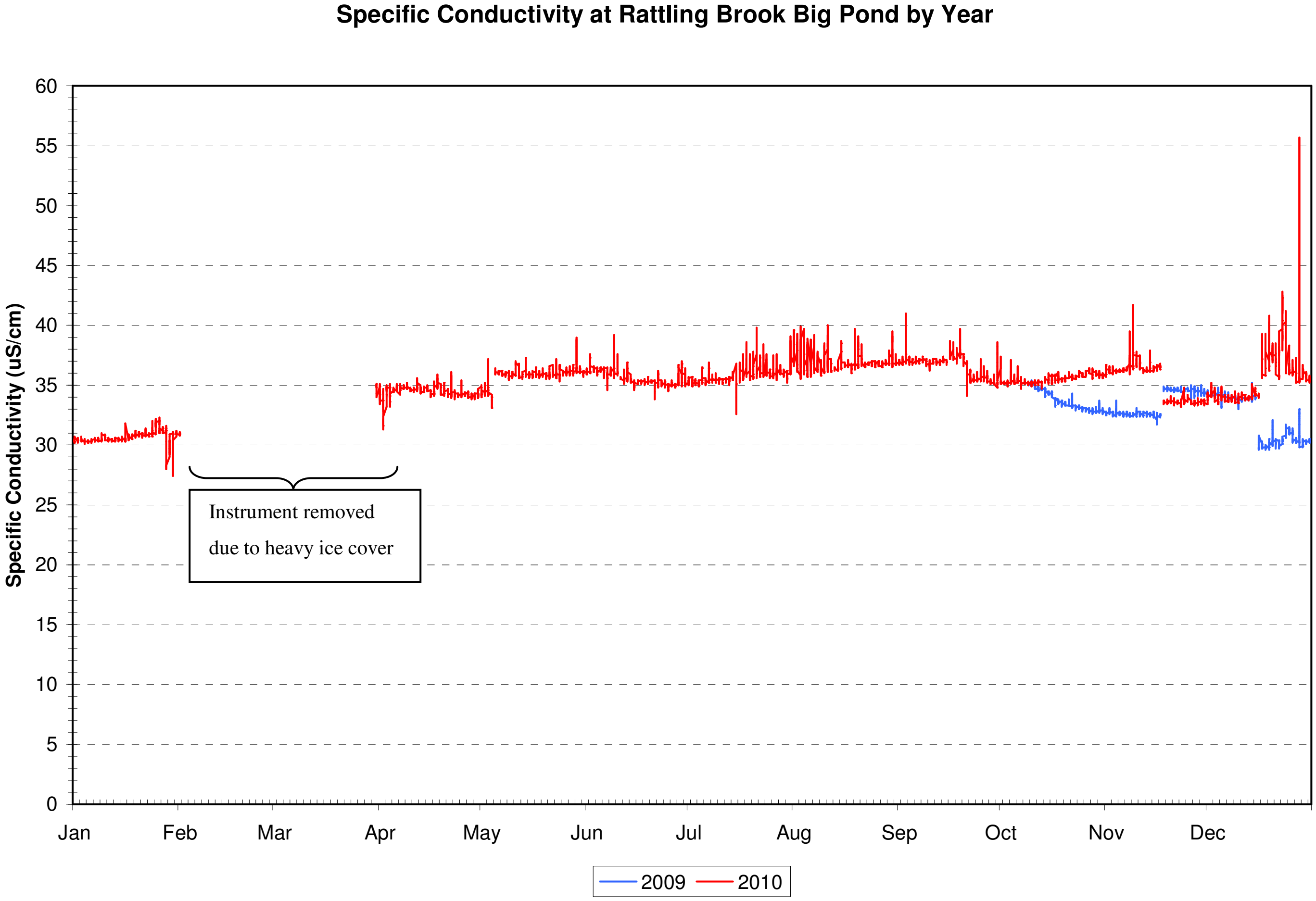
**Figure 3: pH at Rattling Brook Big Pond, 2009 – 2010**




## Specific Conductivity

Though the specific conductivity recorded in the latter part of 2009 is lower than the corresponding values in 2010, it appears that specific conductivity is increasing throughout 2010 (Figure 4). Since Big Pond is in an ideal location due to lack of nearby construction, a general rise in conductivity is not expected. This will continue to be monitored for any potential issues that should be addressed. A range of 27.4 to 55.7 µS/cm was recorded through the year with a median value of 35.6 µS/cm (90% CI: 35.6 – 35.6 µS/cm).

**Figure 4: Specific Conductivity at Rattling Brook Big Pond, 2009 – 2010**

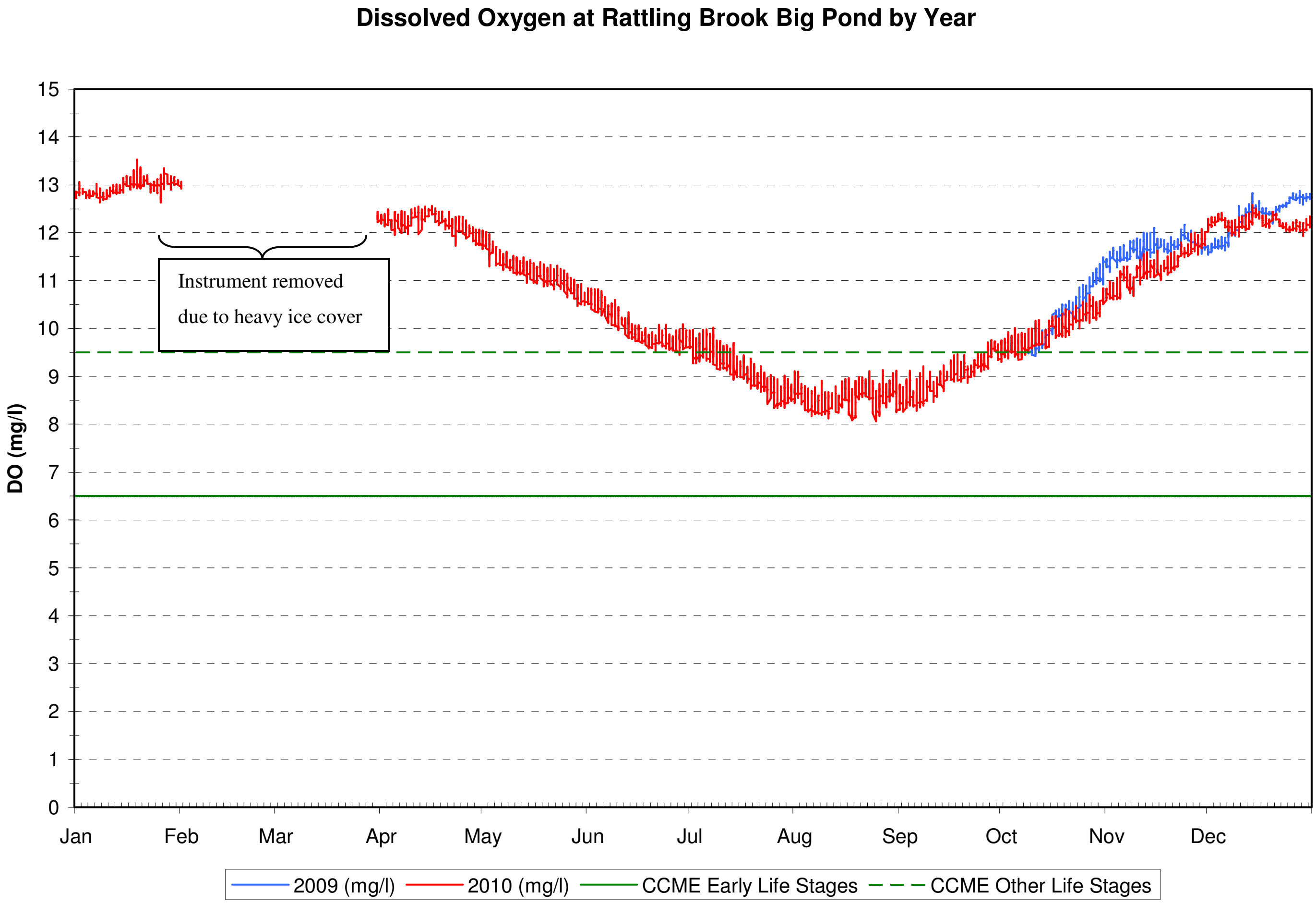



## Dissolved Oxygen

Dissolved oxygen concentrations appear to have been slightly higher in 2009 compared to 2010 levels for much of October through December – likely due to cooler air and water temperatures. It was found that no values declined below the CCME guidelines for the protection of Early Life Stages (DO = 6.5 mg/l). This ensures that aquatic organisms, in the most sensitive period of development, are not exposed to conditions that could hamper survival.

Concentration values were found to range from 8.06 to 13.53 mg/l with a median value of 10.69 mg/l (90% CI: 93.9 – 94.0 mg/l). Notable and natural trends are recognized in Figure 5: DO concentrations are highest throughout the cool fall, winter and spring months with annual lows recorded in August.

**Figure 5: Dissolved Oxygen at Rattling Brook Big Pond, 2009 – 2010**

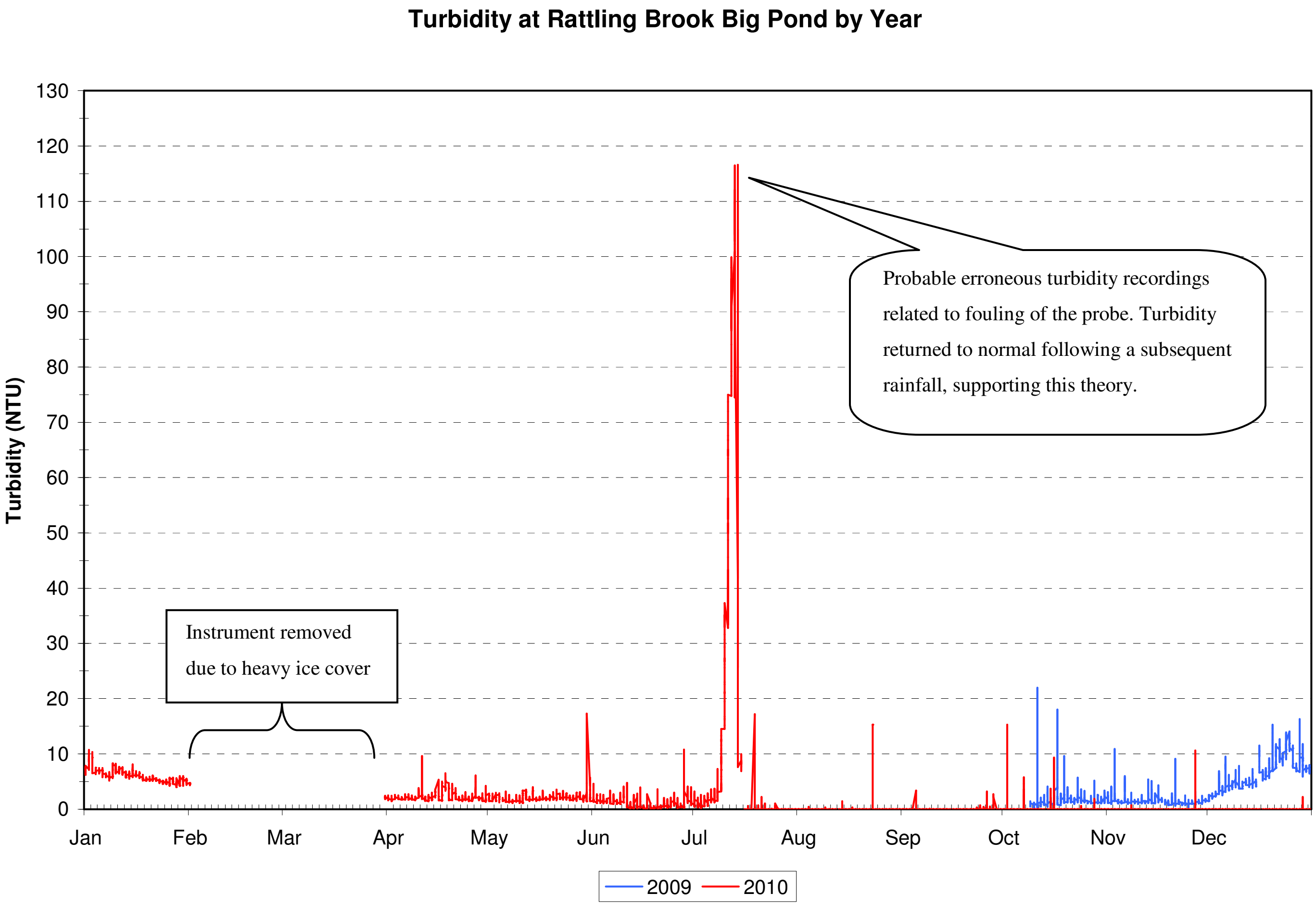



## Turbidity

Very little was recorded in terms of turbidity in 2010. By far, most values were free of turbidity since the calculated median is 0.0 NTU (90% CI: 0.0 – 0.0 NTU). A range of 0.0 to 116.6 NTU was observed. Occasional spikes are recorded during precipitation events, but the probable cause in most instances is sediment stirred up by wave action or chance blockage by drifting debris.

In July, the annual maximum was encountered. It has been determined that this plateau (indicated in Figure 6) is probably related to biofouling of the sensor as opposed to as true readings since turbidity drops abruptly following a rainfall event indicating wave action and water influx may have cleared the sensor.

**Figure 6: Turbidity at Rattling Brook Big Pond, 2009 – 2010**

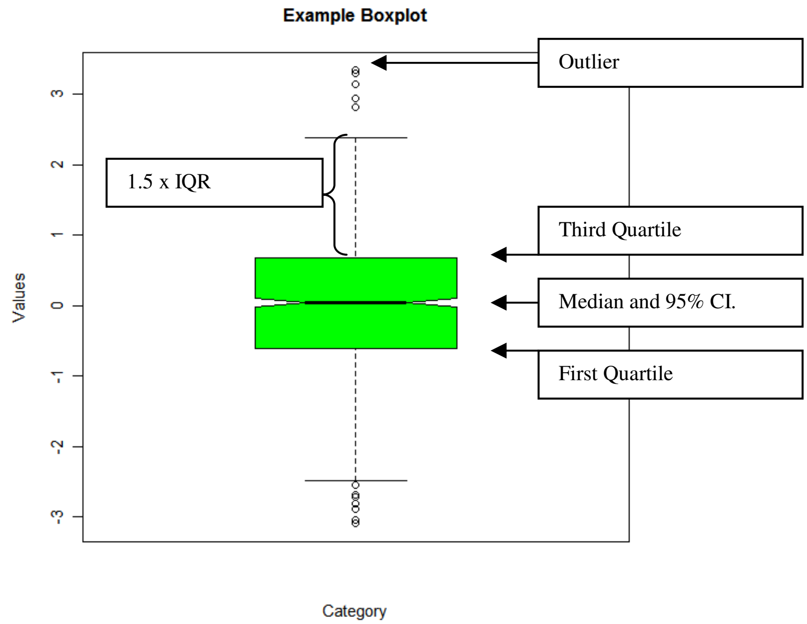



## Rattling Brook below Bridge

Three full years of data have been gathered by this station (2008, 2009, 2010) making it the most useful dataset to base any observations of change on.

A series of boxplots are included for each parameter. A boxplot is useful for illustrating the range of values encountered and presenting the skew of a distribution through the relative placement of first, second (median) and third quantiles. Outliers, or extreme values, are expressed as individual hollow circles once they are outside 1.5 times the interquartile range (IQR). See Figure 7 for details.

**Figure 7: Anatomy of a Boxplot**




## Water Temperature

Figure 8 illustrates water temperatures for 2008 through 2010. During these three years, water temperature appears to be very similar with a great deal of overlap. Notably, the only times where temperatures appear to be highly variable is late November through January where large swings in daily air temperature are the norm. On an annual basis, however, the range for each year is very similar given the large overlap in boxplots in Figure 9).

In 2010 water temperature ranged from -0.5 to 22.84°C with a median of 7.73°C (90% CI: 7.51 – 7.94 °C).

**Figure 8: Water Temperature at Rattling Brook below Bridge, 2008 – 2010**

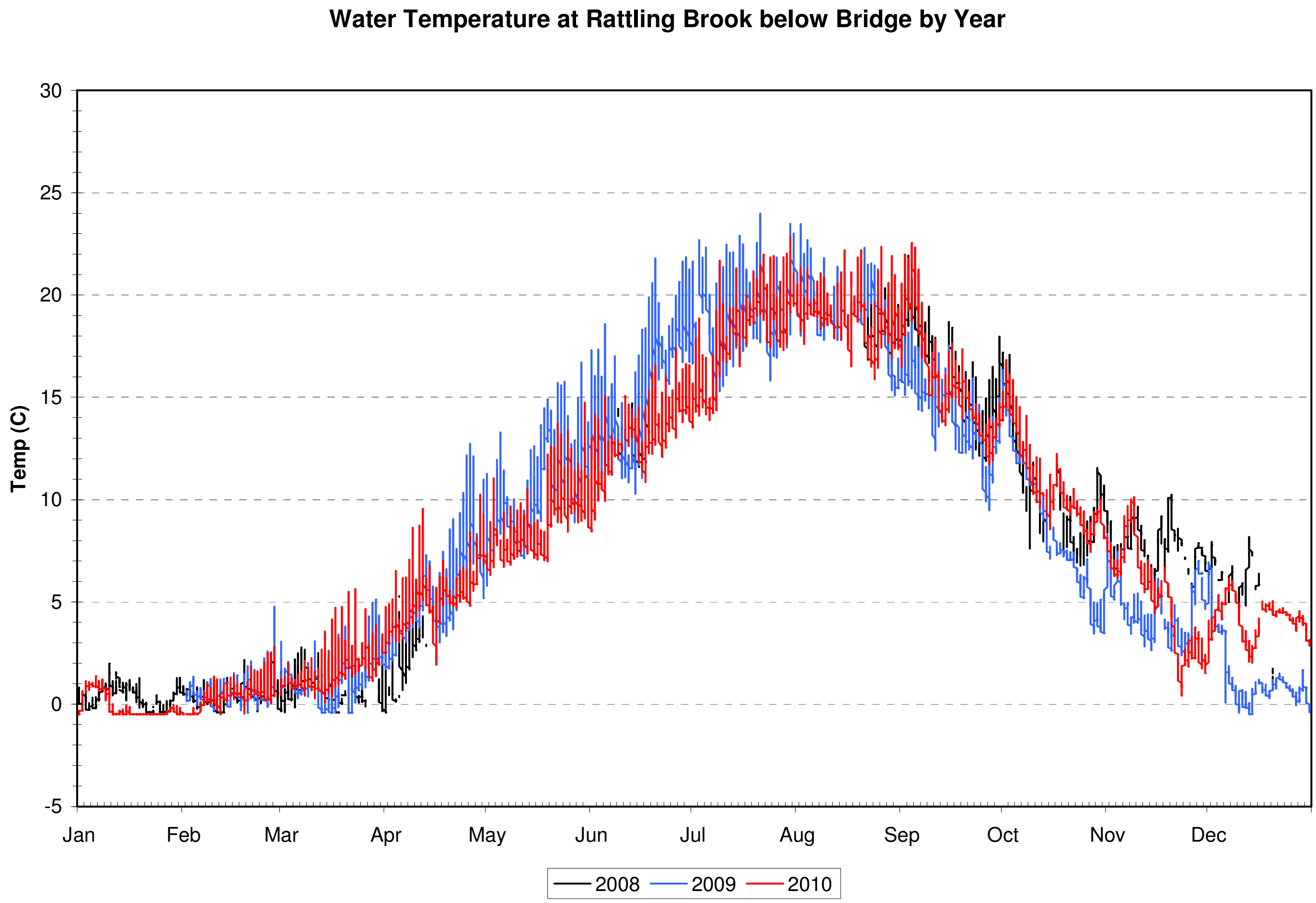
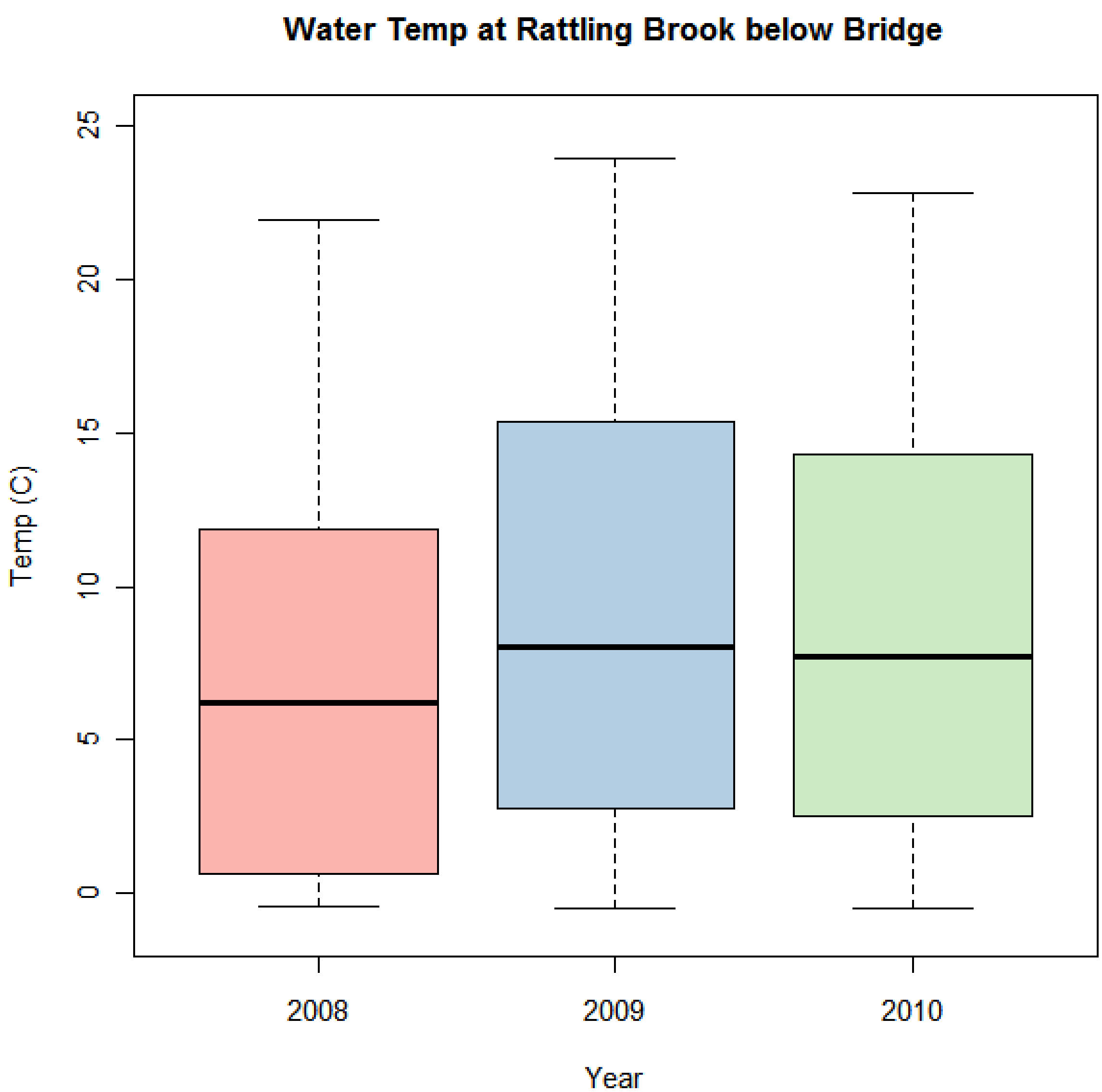


**Figure 9: Boxplots of Water Temperature for 2008 – 2010 at Rattling Brook below Bridge**




pH

A narrow pH range is ideal in aquatic systems. Enzymatic reactions and structural proteins can be critically altered in large acidic or alkaline shifts. Furthermore, the pH of a solution often determines the extent of solubility for metal ions and carbonaceous compounds. Fortunately, pH at Rattling Brook below Bridge appears to be comparable to previous years. An examination of Figure 10 shows that pH for the last three years overlaps to a large extent; however, a slight increase in alkalinity during 2010 may be apparent in Figure 11. It is possible that the increase seen in 2010 is simply due to natural variability in Rattling Brook since no trend can be observed in the range of pH from 2008 onwards. This will be watched closely over the course of the following year.

**Figure 10: pH at Rattling Brook below Bridge, 2008– 2010**

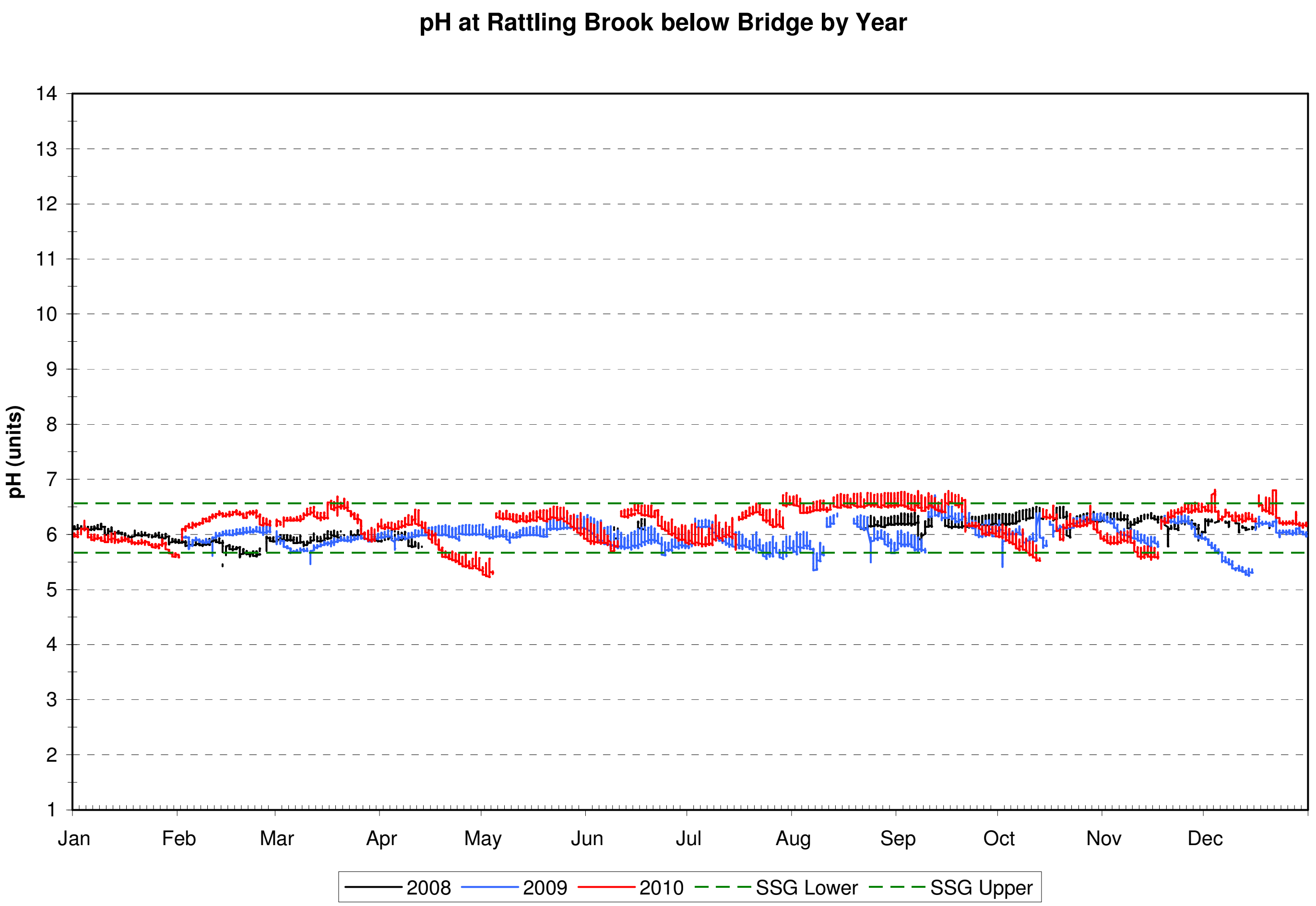
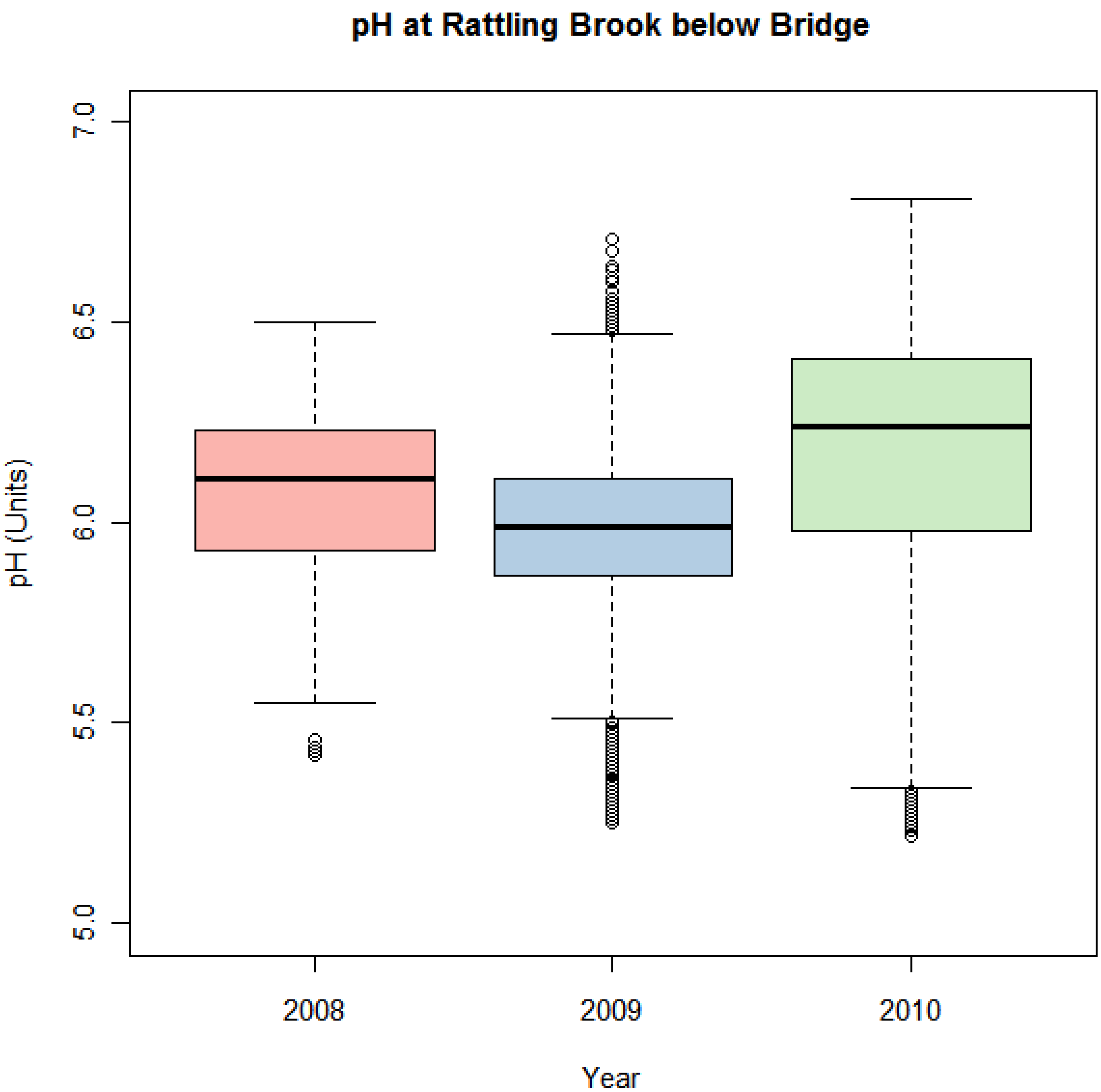


**Figure 11: Boxplots of pH for 2008 – 2010 at Rattling Brook below Bridge**




<u>Specific Conductivity</u>

Specific conductivity has been notably higher at Bridge station in 2009 and 2010 compared to 2008. Increasing ionic content in Rattling Brook is likely the result of clear cutting and removal of unsuitable materials from the plant site. While an increase in conductivity is not necessarily a sign of poor water quality, it is an indication that an impact is being recorded by development in the area.

In 2010, conductivity was found to range from 27.4 to 83.6 µS/cm with a median of 35.6 µS/cm (90% CI: 35.6 – 35.6 µS/cm). As shown in the boxplots depicted in Figure 12, it is notable that values identified as outliers are increasingly elevated compared to prior years. This highlights the importance of protecting Ratting Brook from silt-laden runoff.

**Figure 12: Specific Conductivity at Rattling Brook below Bridge, 2008– 2010**

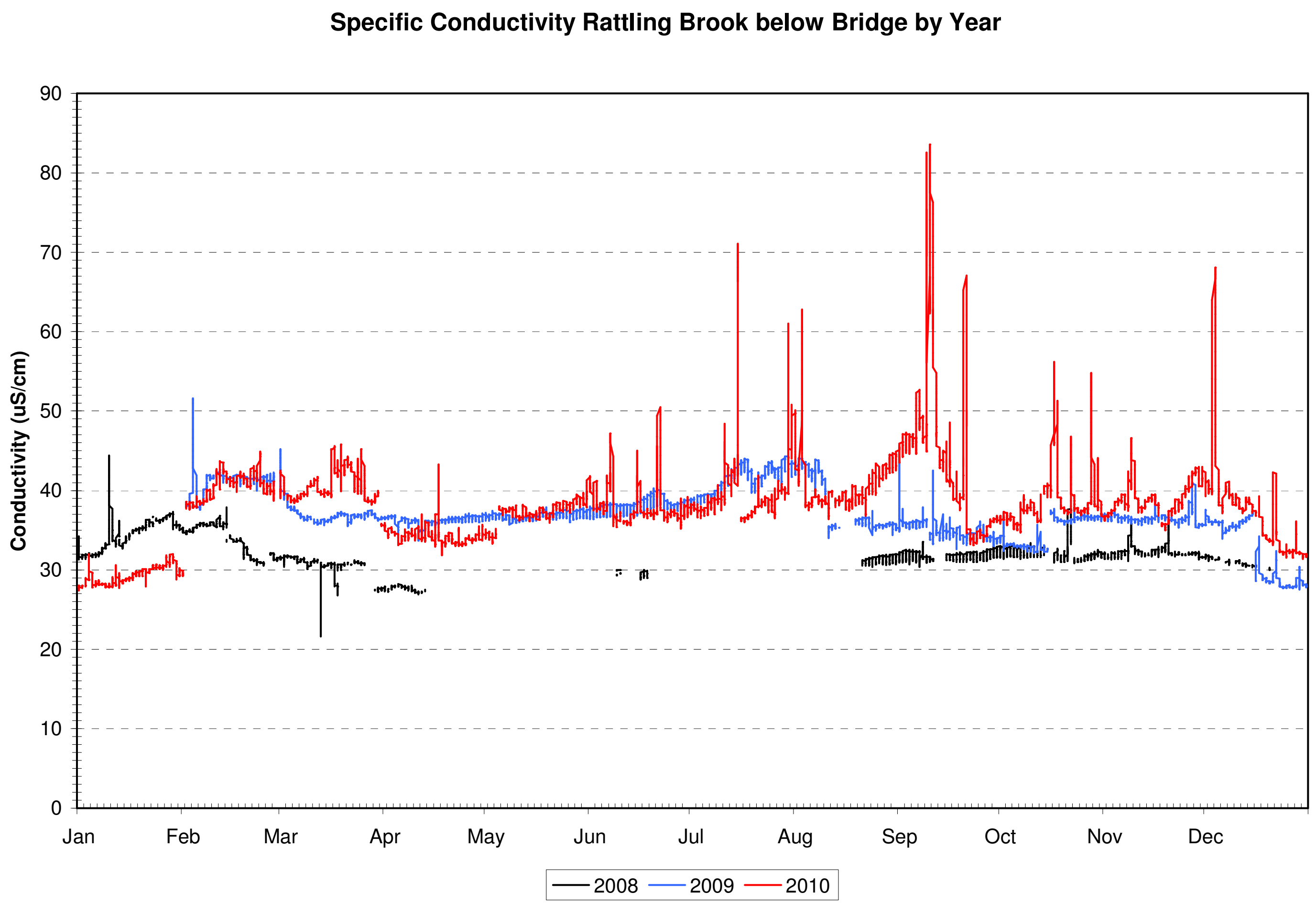
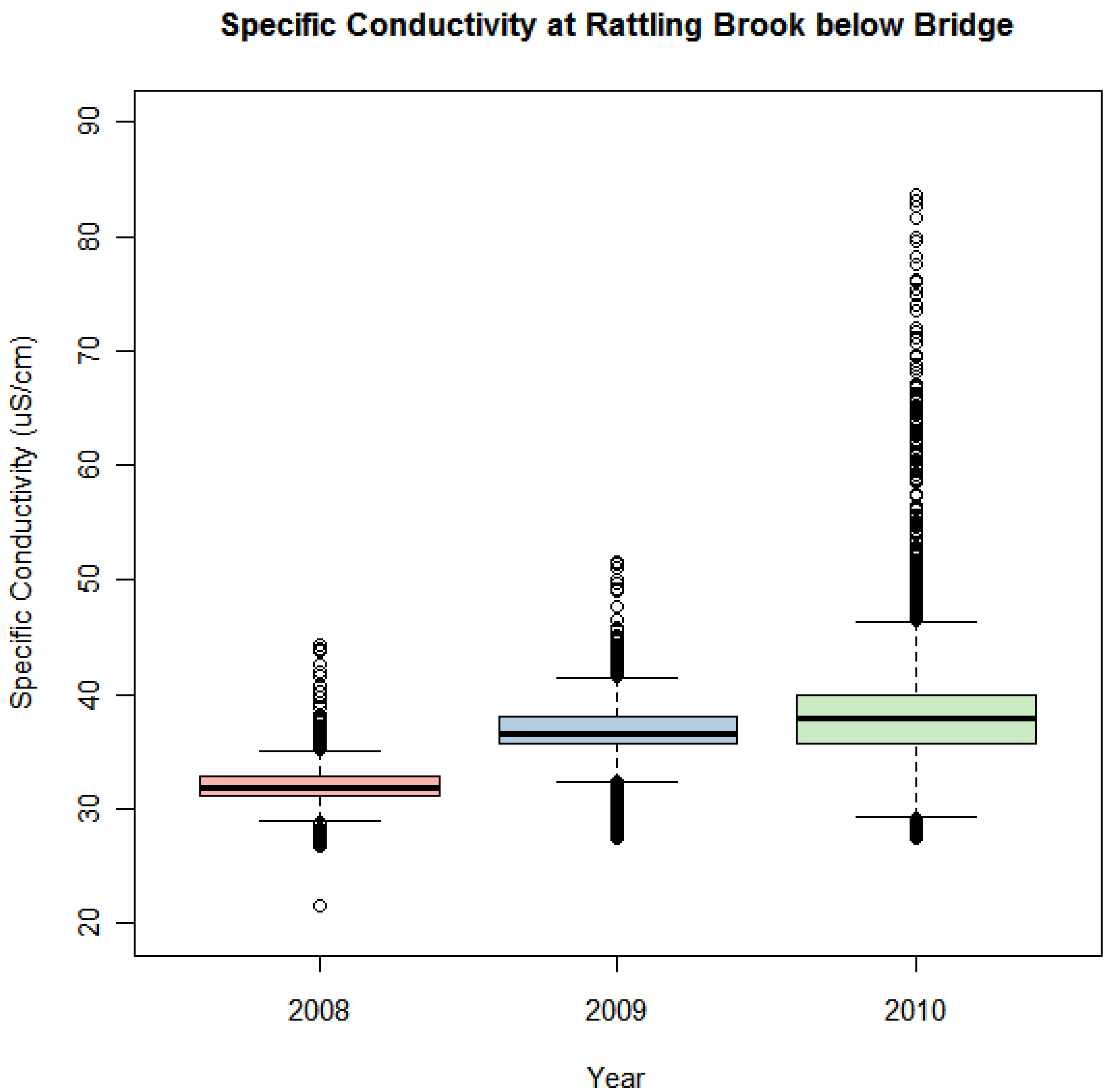


**Figure 13: Boxplots of Specific Conductivity for 2008 – 2010 at Rattling Brook below Bridge**




Dissolved Oxygen

DO concentration values are highly consistent in a year-to-year comparison. Throughout most of 2010, DO coincided very well with previous years (Figure 15), except for some variability during the winter months of November through January (Figure 14).

In 2010, the recorded values ranged from 7.81 to 14.9 mg/l with a median value of 10.69 mg/l (90% CI: 10.62 – 10.76 mg/l). At no time did the DO concentrations decline below the CCME guideline for the protection of early life stage cold water biota (lower dashed green line in Figure 14).

**Figure 14: Dissolved Oxygen at Rattling Brook below Bridge, 2008– 2010**

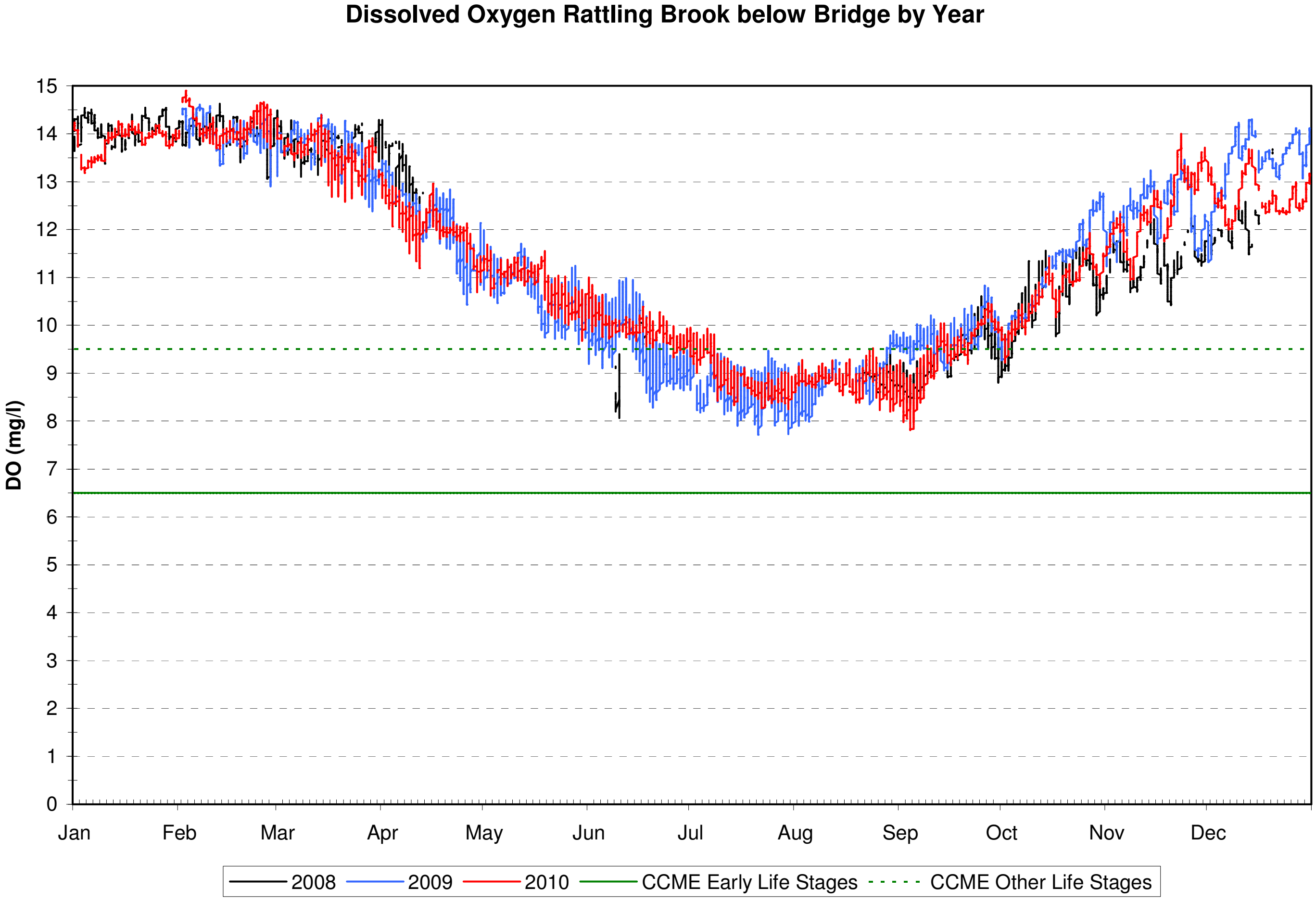
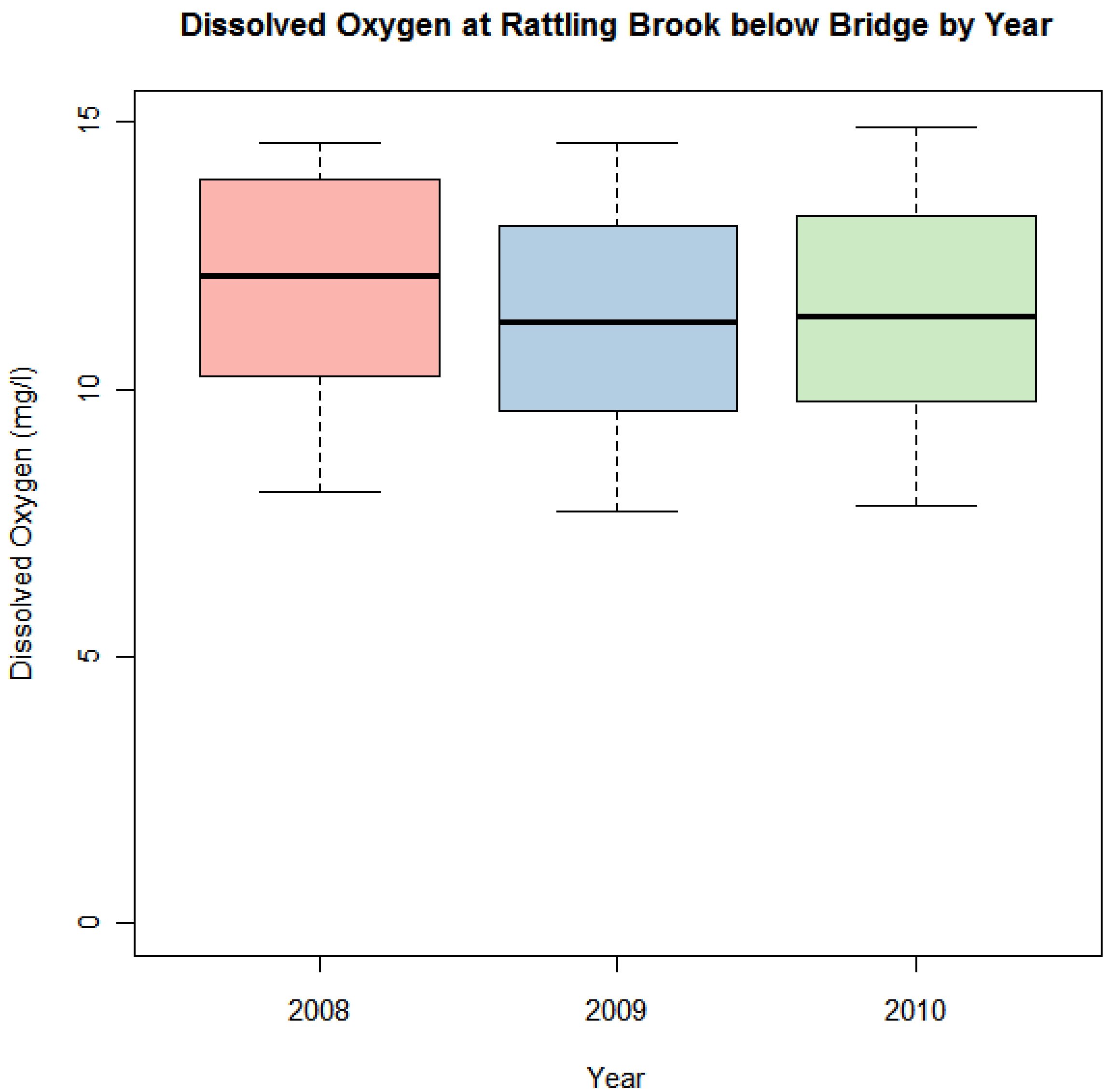


**Figure 15: Boxplots of Dissolved Oxygen for 2008 – 2010 at Rattling Brook below Bridge**




<u>Turbidity</u>

At Rattling Brook below Bridge station, a turbidity alert threshold of 75 NTU has been established. In 2010, turbidity ranged from 0.0 to 445 NTU with a median of 2.51 NTU (90% CI: 2.30 – 2.70 NTU). This places the majority of turbidity readings far below the alert threshold value specified by the Department of Environment and Conservation.

Notably, however, turbidity for the past two years (during ground works) was higher than in 2008 prior to the start of construction. Turbidity started to increase notably in July of 2009 and continued to be elevated until

June 2010. At this point, it appears from Figure 16 that turbidity began to fall. Figure 17 illustrates the range of values seen in 2008 – 2010 where turbidity is increasing year to year as seen by the expanding boxes. It is expected that as construction changed from primarily ground works to infrastructure, there will be a corresponding decrease in turbidity. This trend will be monitored closely as there could be implications for silt management.

**Figure 16: Turbidity at Rattling Brook below Bridge, 2008– 2010**

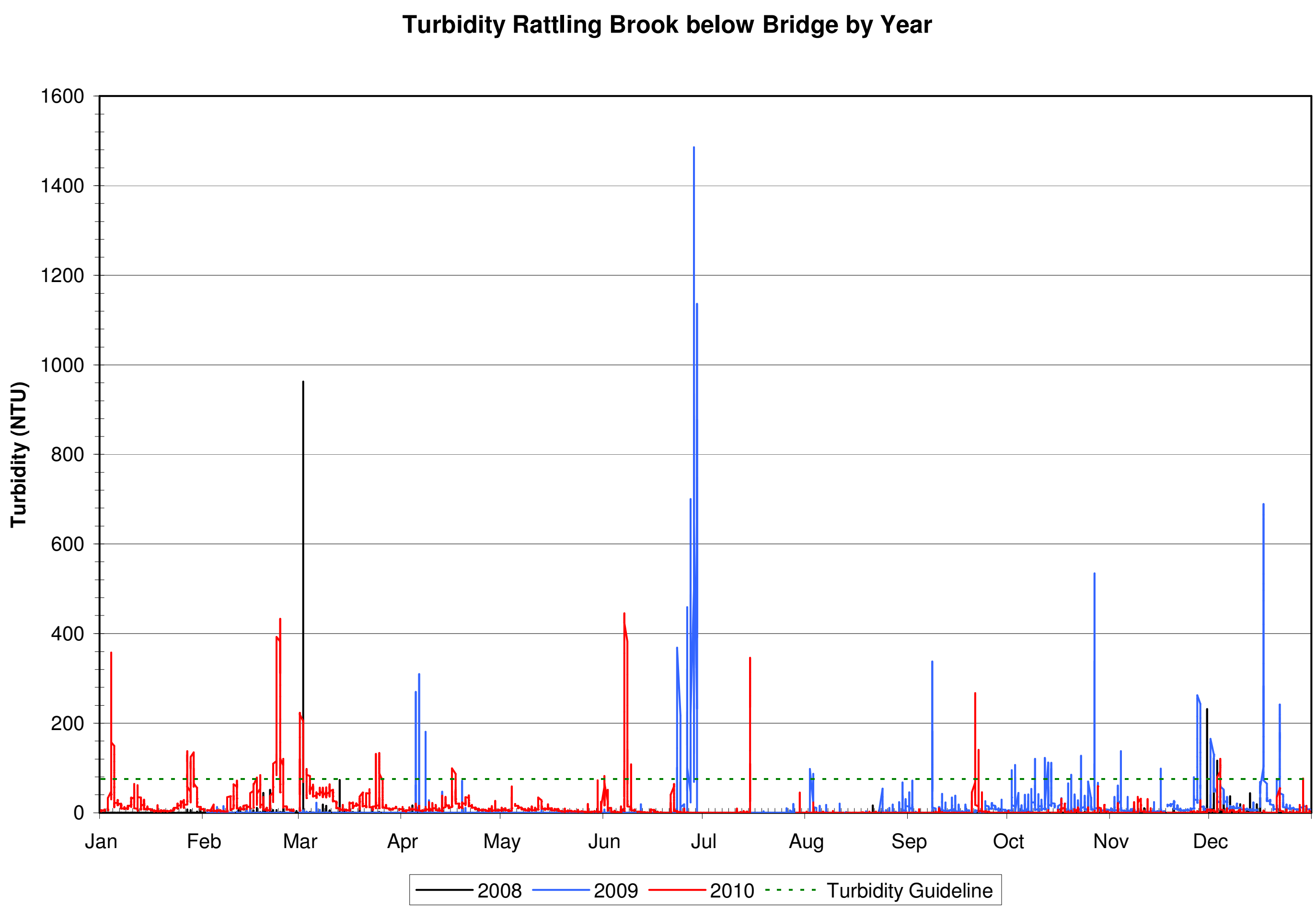
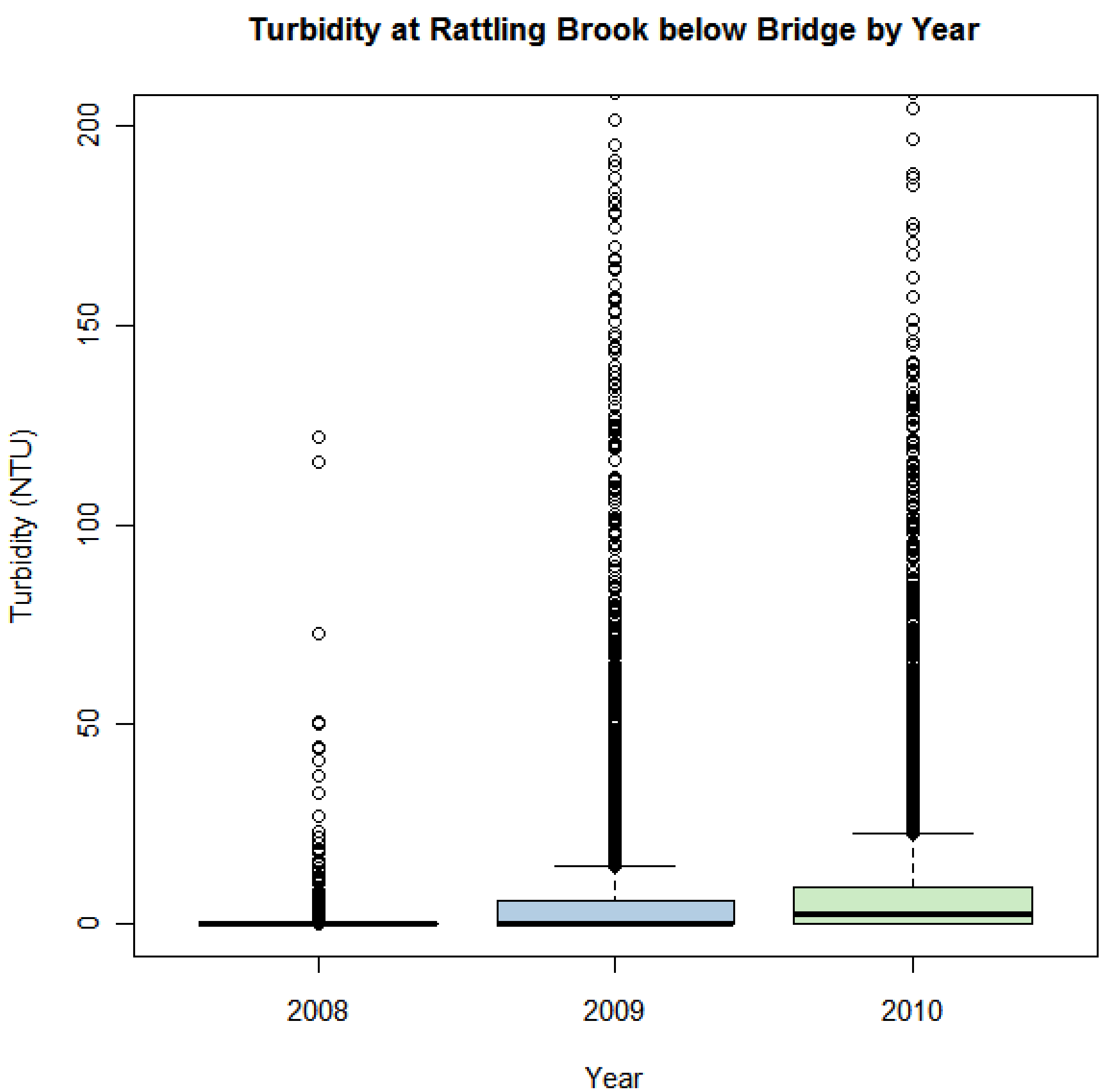


**Figure 17: Boxplots of Turbidity for 2008 – 2010 at Rattling Brook below Bridge**



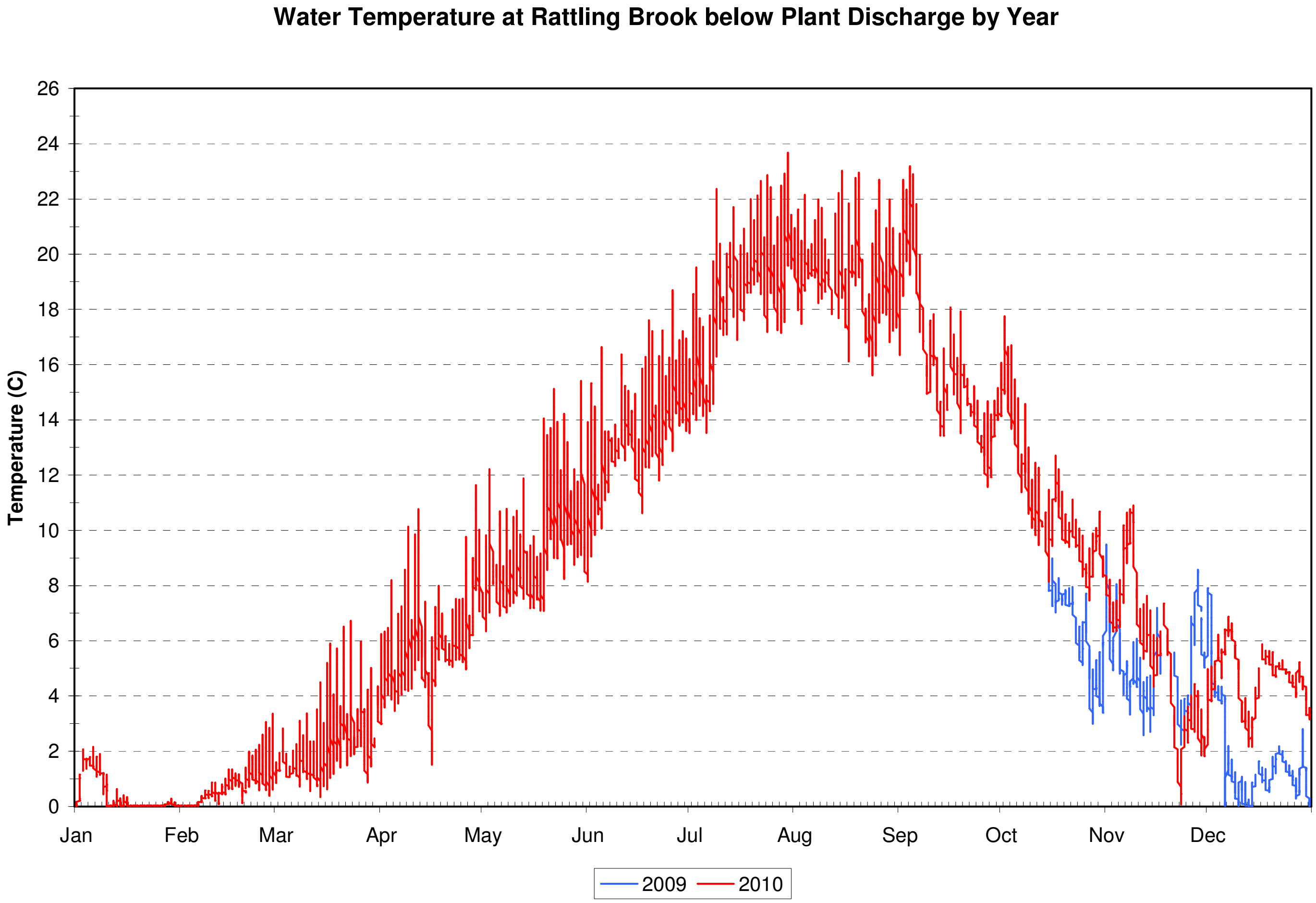

**Rattling Brook below Plant Discharge**

The third station in the system, Rattling Brook below Plant Discharge, has been devised to intercept and monitor the river for influence due to storm water coming from the plant site. This station was commissioned along with the Big Pond station in October 2009 and provides a near-complete view of potential impact on Rattling Brook from construction efforts in the area.

## Water Temperature

A range of 0.02 to 23.67°C (median: 8.11°C; 90% CI: 7.89 – 8.32°C) was established at Rattling Brook below Plant Discharge station in 2010. The warmest temperatures were found to occur in late July with the minimum encountered in January and February.

**Figure 18: Water Temperature at Rattling Brook below Plant Discharge, 2009 – 2010**



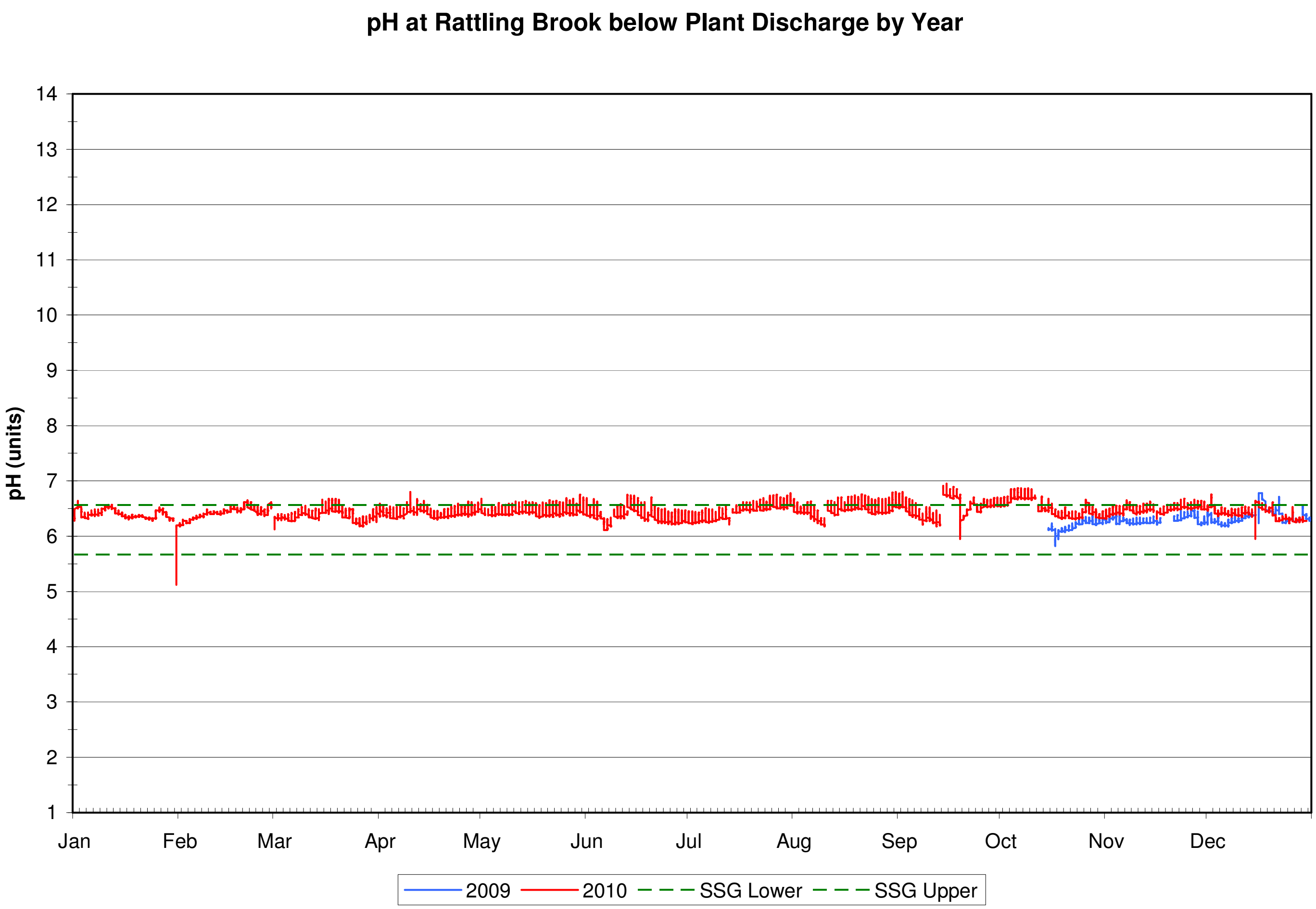

## pH

In 2010, pH values ranged between 5.95 and 6.95 units (median: 6.44; 90% CI: 6.44 – 6.45).

Most pH values fell within the newly constructed Site Specific Guideline of 5.67 – 6.56 units for 2010, however, it was not uncommon for pH to exceed the upper guideline. Given that the three months of reading from 2009 were largely less than the concurrent 2010 values, it is possible that a general increase in pH is responsible for the frequent upper-limit breaches.

Over the 2011 year, an examination of this trend will be made and the SSGs could be split to differentiate between Plant Discharge and Bridge/Pond stations.

**Figure 19: pH at Rattling Brook below Plant Discharge, 2009 – 2010**

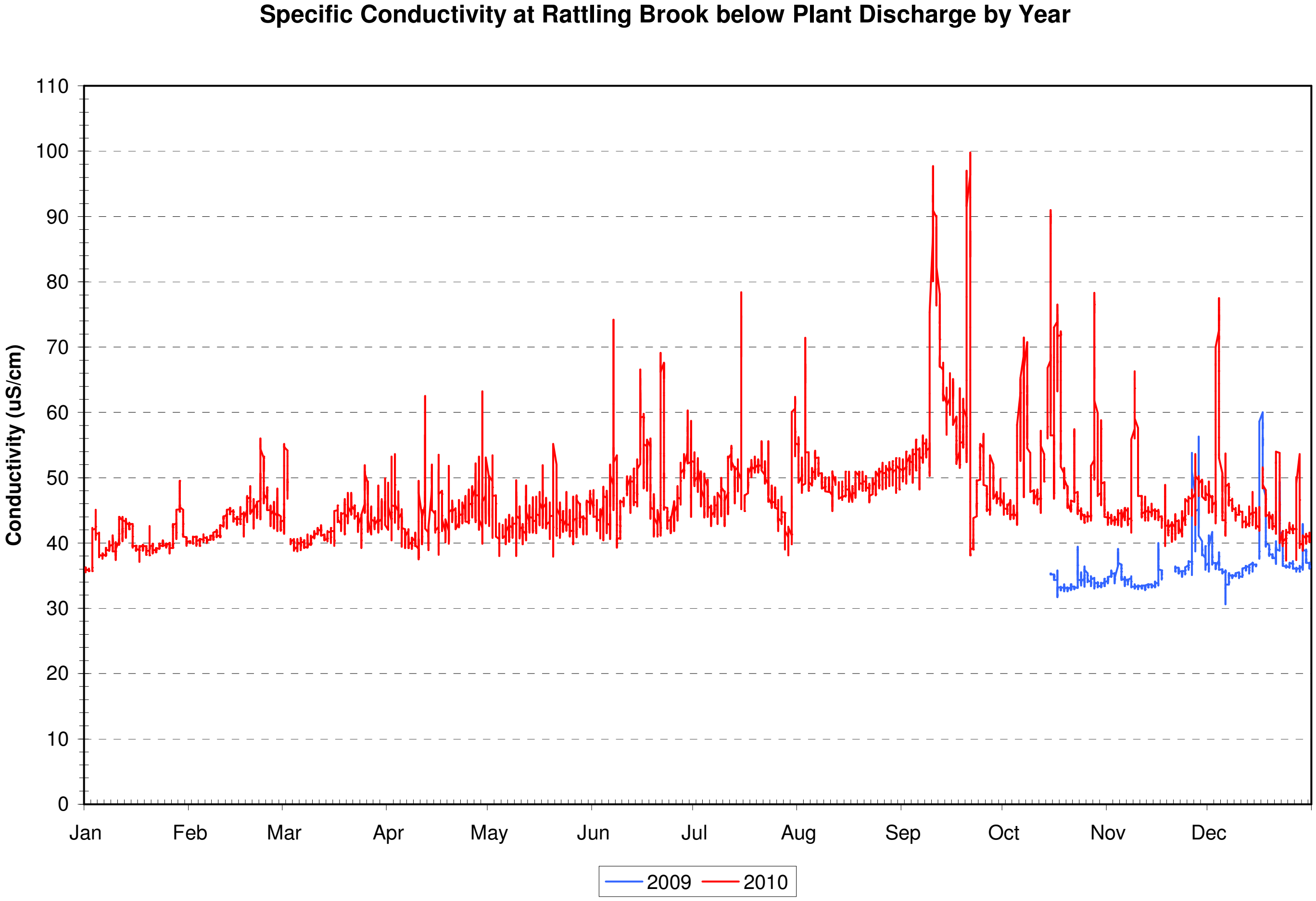



## Specific Conductivity

A brief examination of conductivity values suggests a rising tendency in the amount of dissolved ions at Rattling Brook below Plant Discharge; corresponding values in 2010 are higher than those in 2009. For 2010, values ranged from 35.5 to 99.8 µS/cm with a median value of 44.86 µS/cm (90% CI: 44.80 – 44.90 µS/cm).

It is possible that the change from major ground works to infrastructure development will result in a decline in specific conductivity as soils begin to settle and storm water management stabilizes.

**Figure 20: Specific Conductivity at Rattling Brook below Plant Discharge, 2009 – 2010**

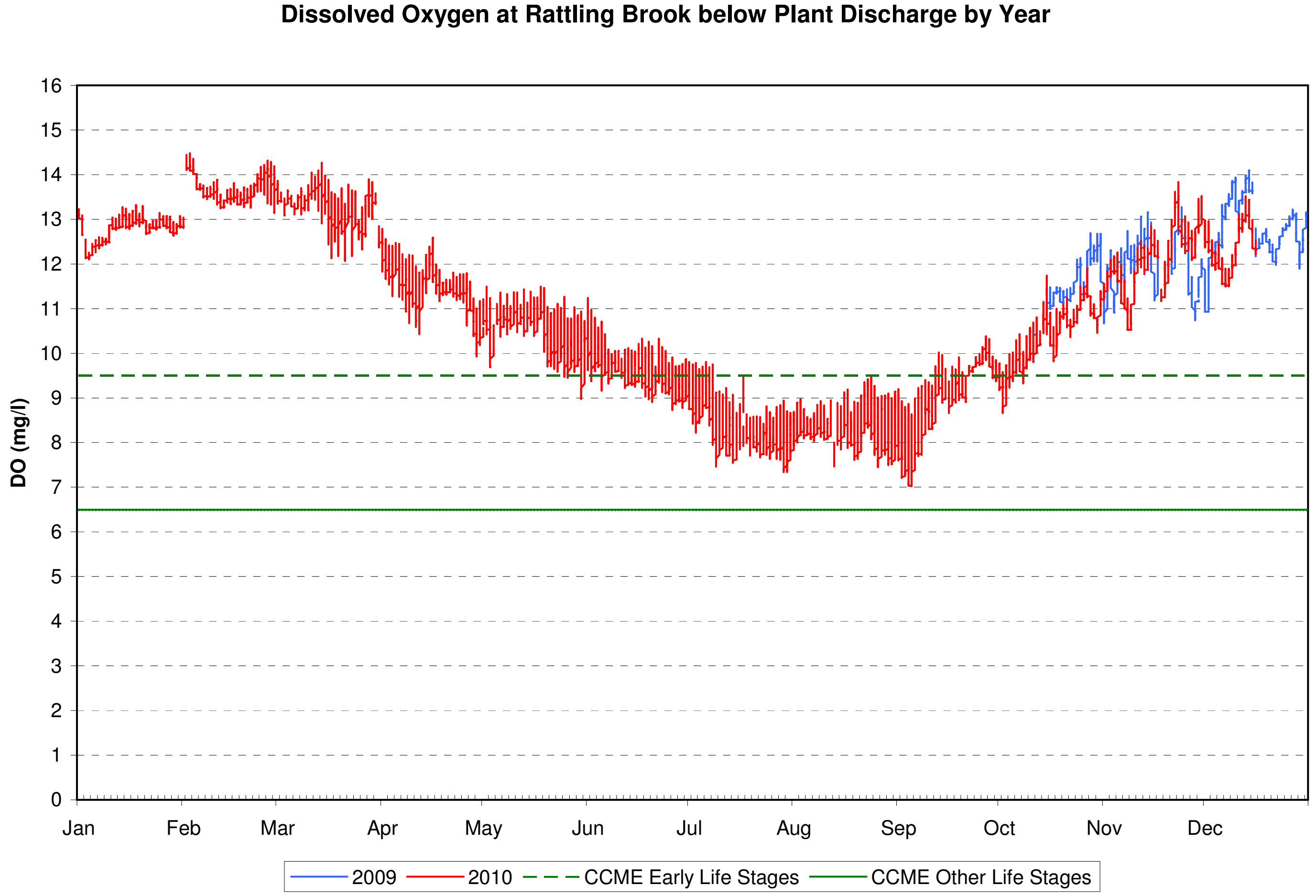



## Dissolved Oxygen

The trend for dissolved oxygen in 2010 was as expected with the highest values recorded in the cold winter months of February and early March. Concentrations began to decline as water temperatures increase from mid-March to July. For the concurrent 2009 and 2010 values, there does not appear to be any meaningful difference.

Values were found to range from 7.02 to 14.48 mg/l with a median value of 10.94 mg/l (90% CI: 94.0 – 94.2 mg/l). All values were found to be above the CCME Guideline for Other Life Stage cold water biota.

**Figure 21: Dissolved Oxygen at Rattling Brook below Plant Discharge, 2009 – 2010**

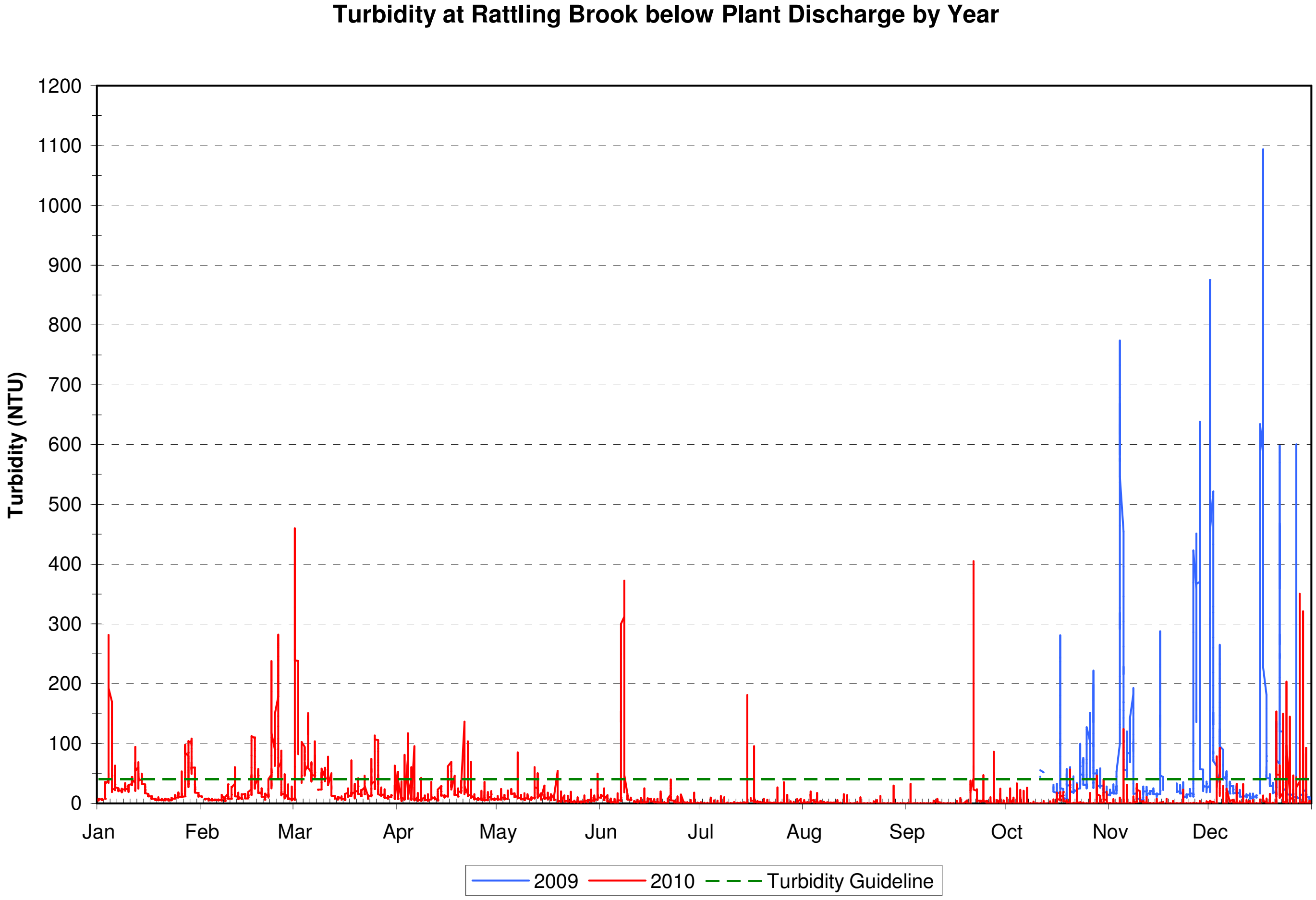



## Turbidity

Concurrent 2009 and 2010 values for October through December indicate that there could be a major decline in the magnitude of turbidity spikes. This is a positive step and is a reflection of expanded storm water handing and settling capacity on site.

In 2010, recorded turbidity ranged from 0.0 to 460 NTU with a median of 3.34 NTU (90% CI: 3.10 – 3.60 NTU). As the year progresses, it is clear that fewer and fewer instances of turbidity above the alert threshold of 40 NTU stated by the Department of Environment and Conservation are being surpassed.

**Figure 22: Turbidity at Rattling Brook below Plant Discharge, 2009 – 2010**




## Comparison by Station

The following graphs and discussion offers a comparison of major water quality parameters by station for 2010. This allows for a glimpse at how water quality parameters change throughout Rattling Brook.

### <u>Temperature</u>

A large degree of overlap is seen in water temperature for all stations in 2010. Water temperatures recorded at pond station indicate a level of stability not seen in the stations further downstream. Bridge and Discharge stations are more prone to extremes due to the shallow, fast-flowing nature of the water in these areas and the greater contact with warm or cold air. Figure 24 shows the degree of similarity in recorded water temperatures at the three stations.

**Figure 23: Water Temperature at Pond, Bridge and Discharge Stations in 2010**

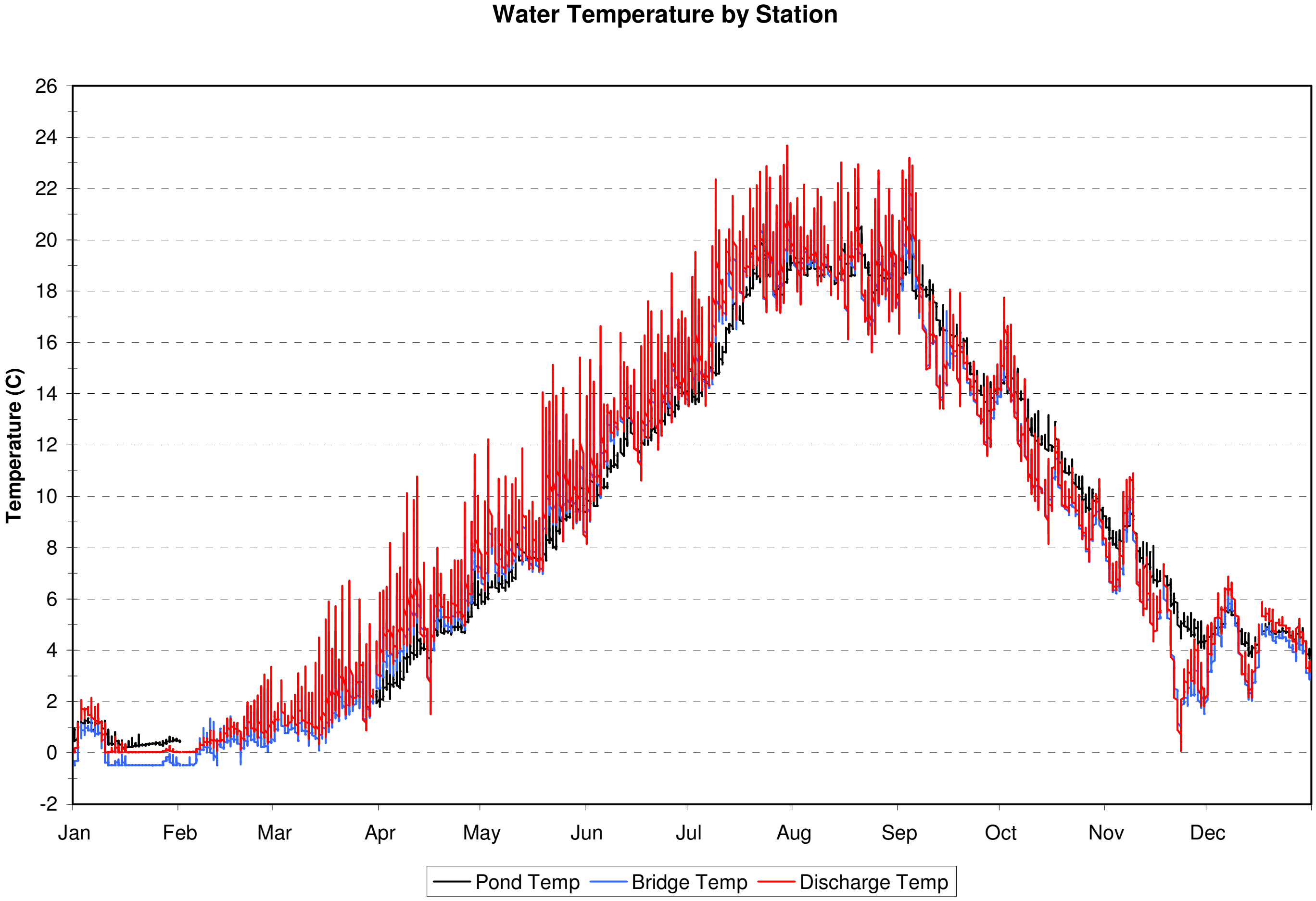
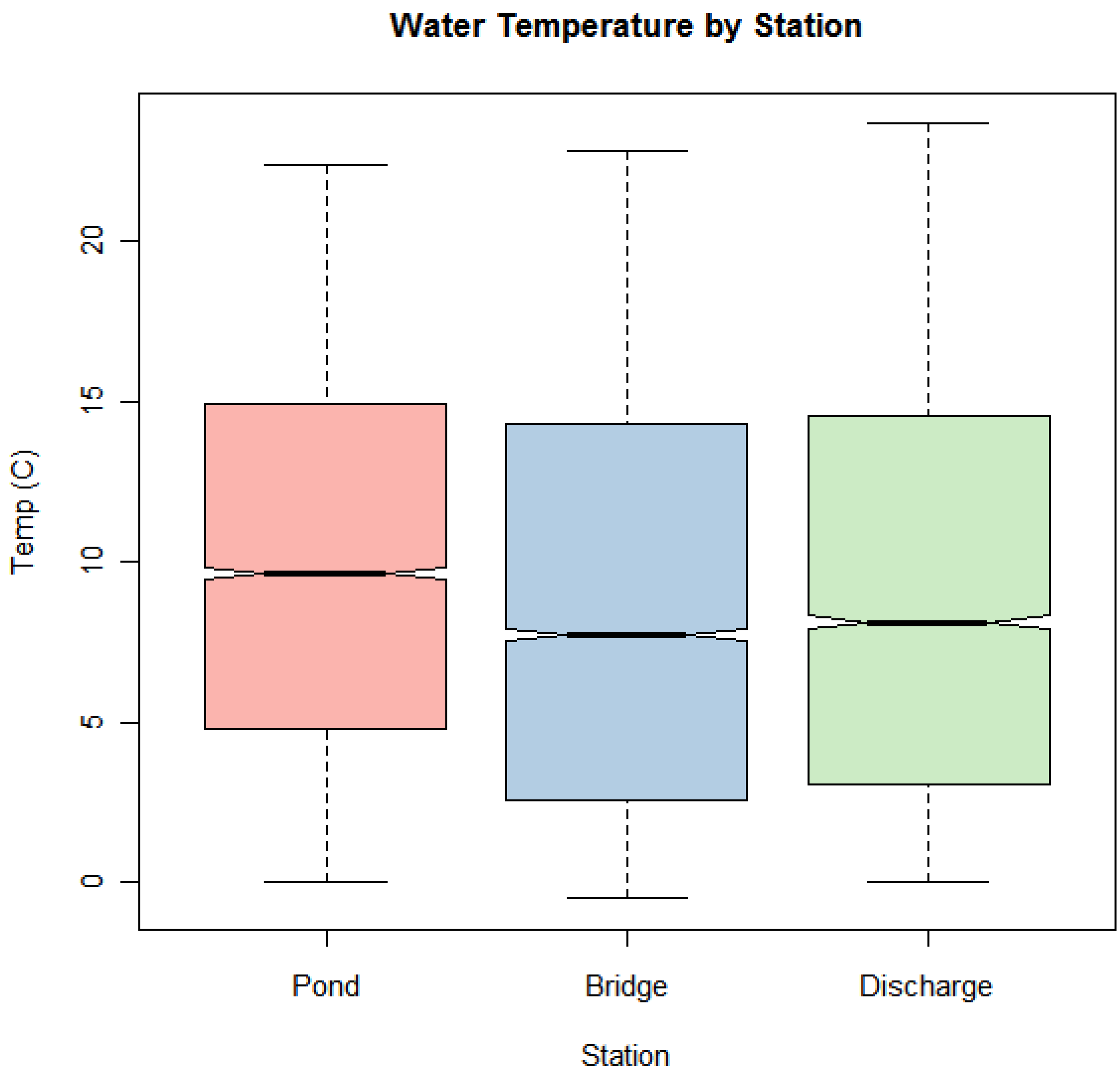


**Figure 24: Boxplots of Water Temperature for Pond, Bridge and Discharge Stations in 2010**




pH

Interestingly, Bridge station appears to have a very broad dispersion in pH values compared to Pond and Discharge stations. Bridge station shows an unusually large variation in pH values that may be due to its placement at the end of a fairly large and shallow riffle with great deal of contact with air (forming slightly acidic carbonic acid). It is also possible that such a range in pH values is due to an aging pH probe on the instrument used at Bridge station. An unusual pattern of pH recordings is seen at bridge station where a decidedly downward trend is observed over the time span of every deployment. This probe has since been replaced and the performance will be monitored throughout 2011.

**Figure 25: pH at Pond, Bridge and Discharge Stations in 2010**

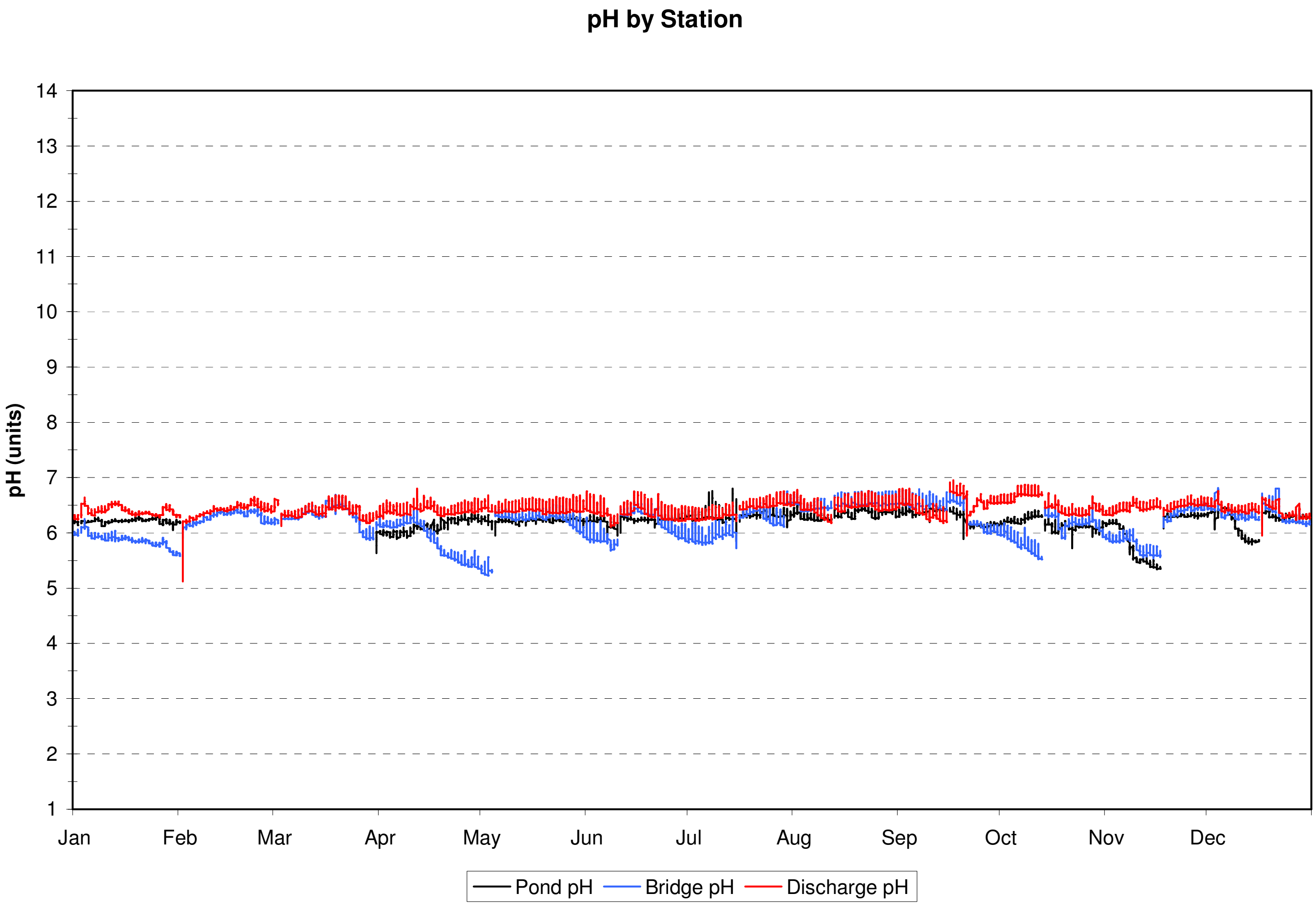
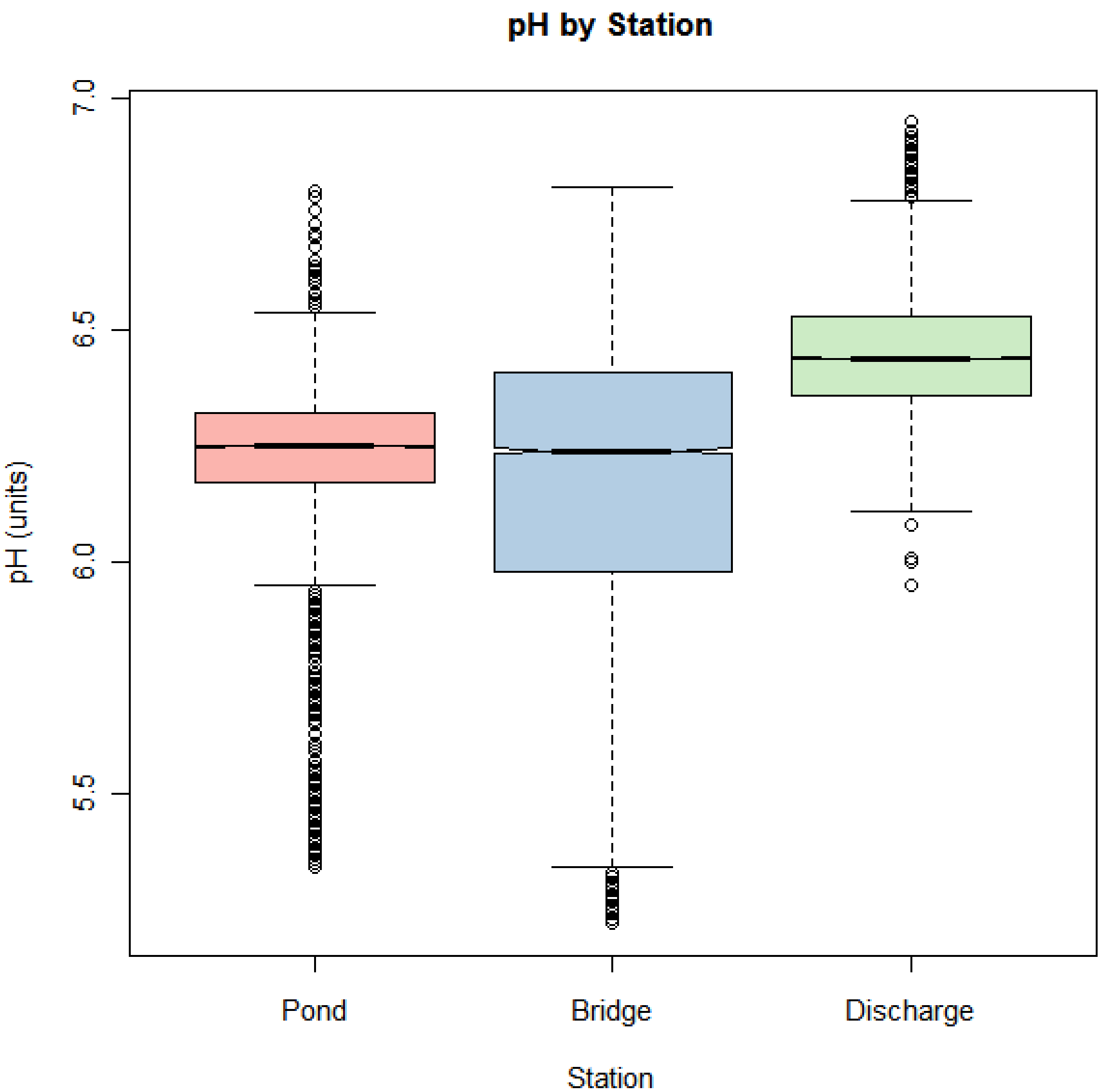


**Figure 26: Boxplots of pH for Pond, Bridge and Discharge Stations in 2010**




## Specific Conductivity

A distinct trend in specific conductivity is observed in Figure 27 when comparing conductivity values. As expected, the longer water flows through a watershed the more ions are dissolved in solution. Furthermore, Rattling Brook experiences more potential impact from construction as it flows from the relatively pristine upper reaches in Big Pond and flows through the construction site towards the ocean. A trend of increasing conductivity is also shown by the expanding boxplots in Figure 28.

**Figure 27: Specific Conductivity at Pond, Bridge and Discharge Stations in 2010**

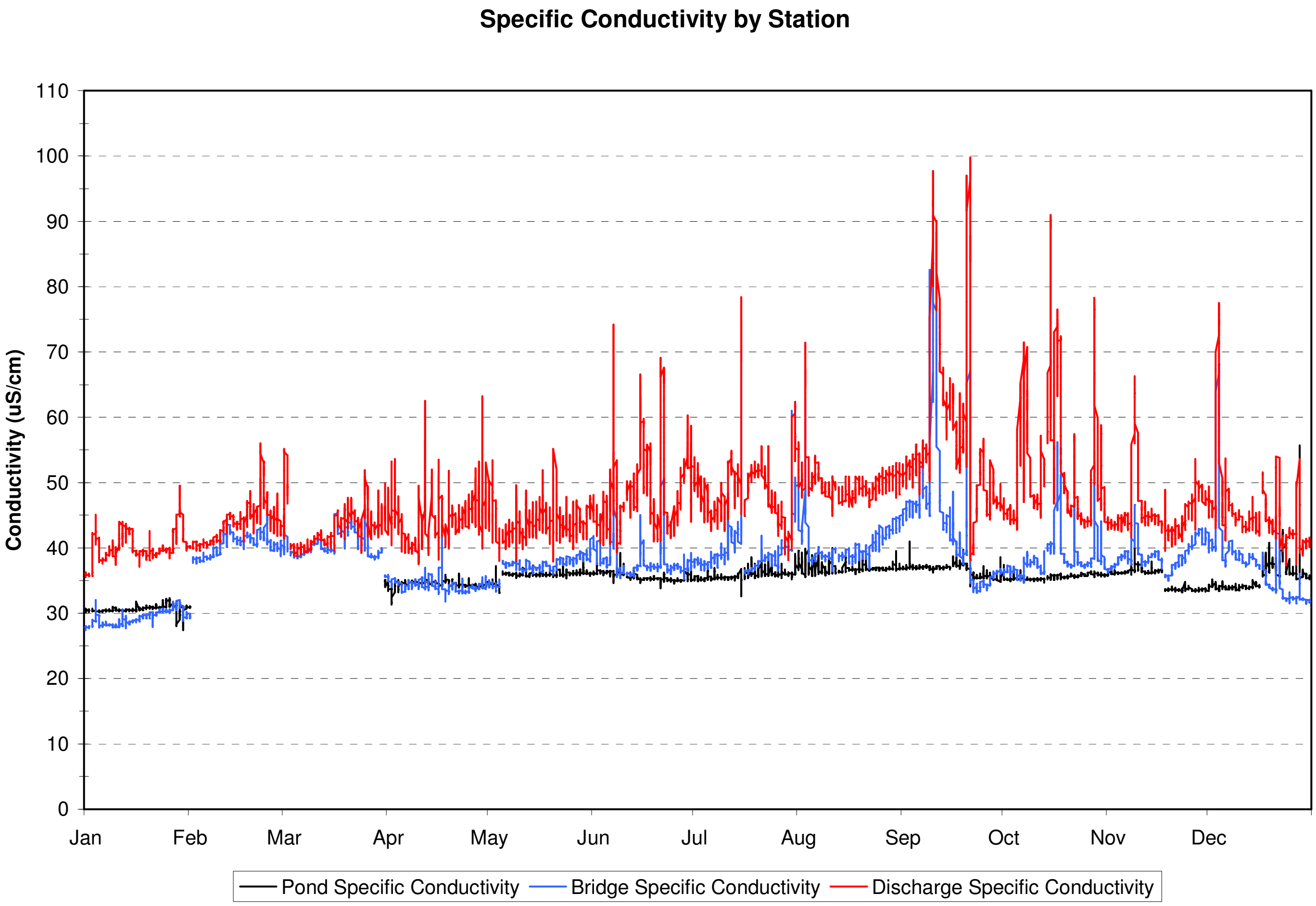
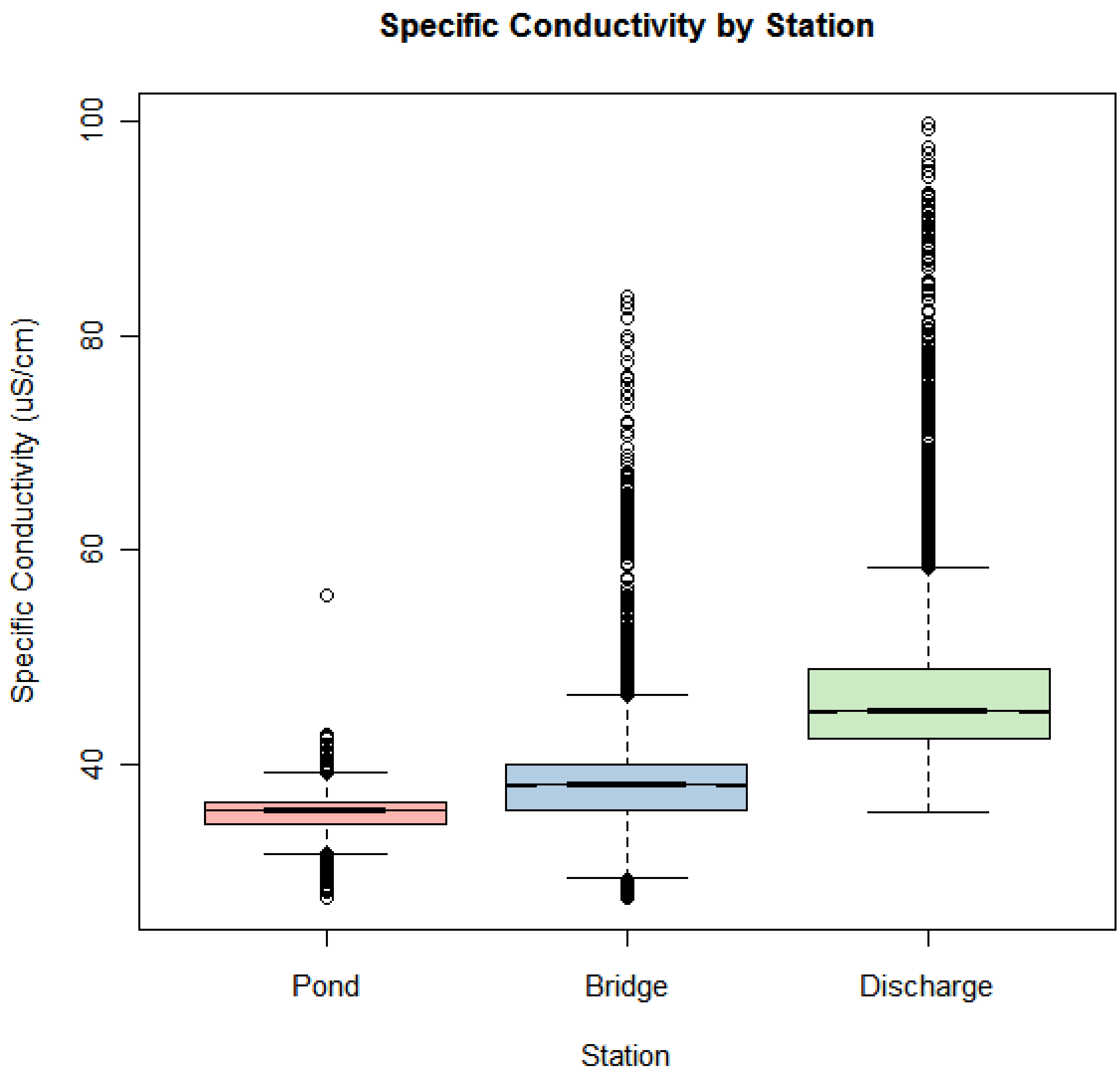


**Figure 28: Boxplots of Specific Conductivity for Pond, Bridge and Discharge Stations in 2010**




## Dissolved Oxygen

Dissolved oxygen values do not differ a great deal between each of the three stations on Rattling Brook. Relatively still and calm waters at Big Pond and below Plant Discharge result in slightly lower DO concentrations whereas the vigorous riffles before Bridge station encourages the solubility of gasses in the water. As water passes through Bridge station a small pond is encountered where water slows and allows for excess DO to degas or be consumed by aquatic organisms.

**Figure 29: Dissolved Oxygen at Pond, Bridge and Discharge Stations in 2010**

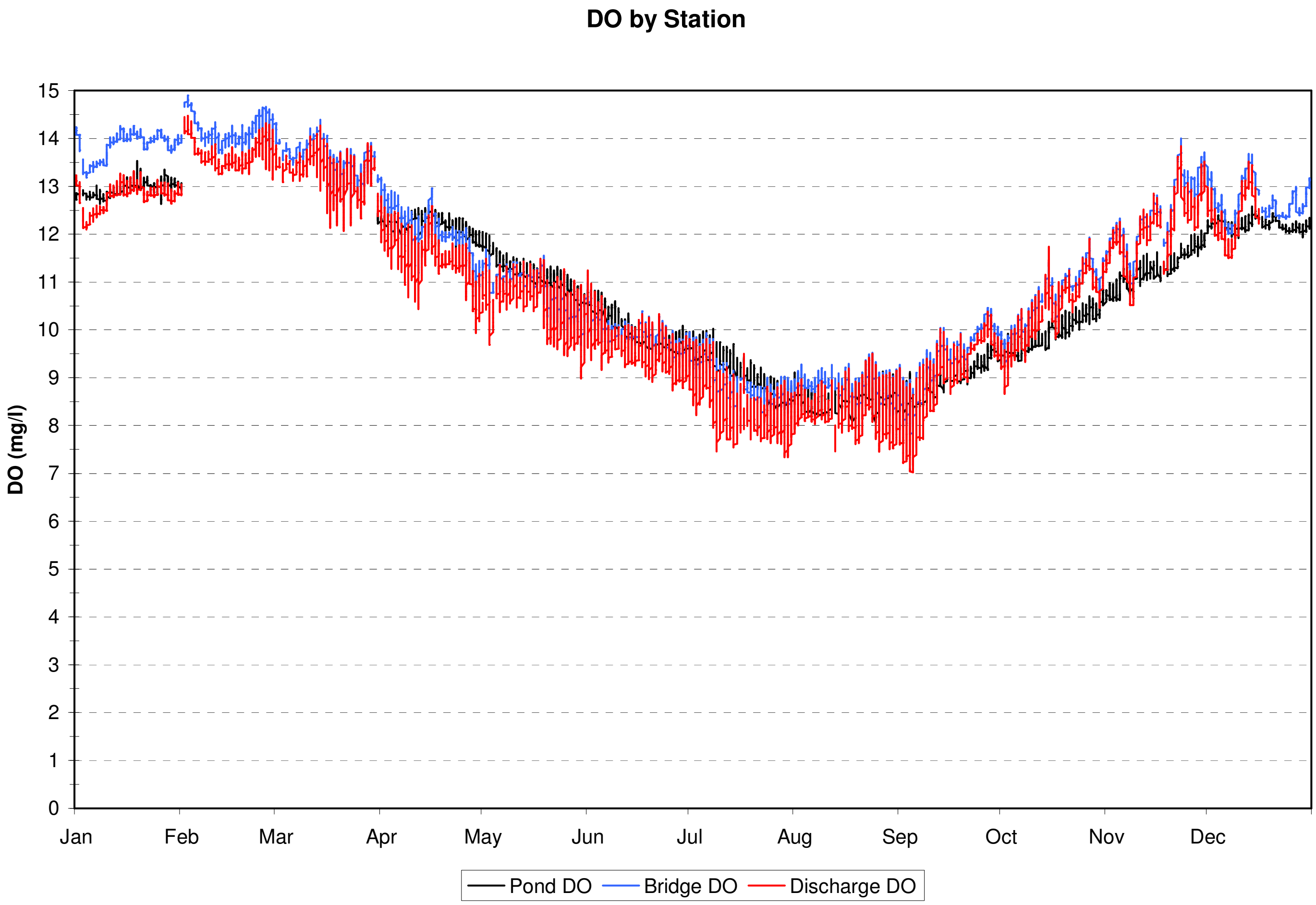
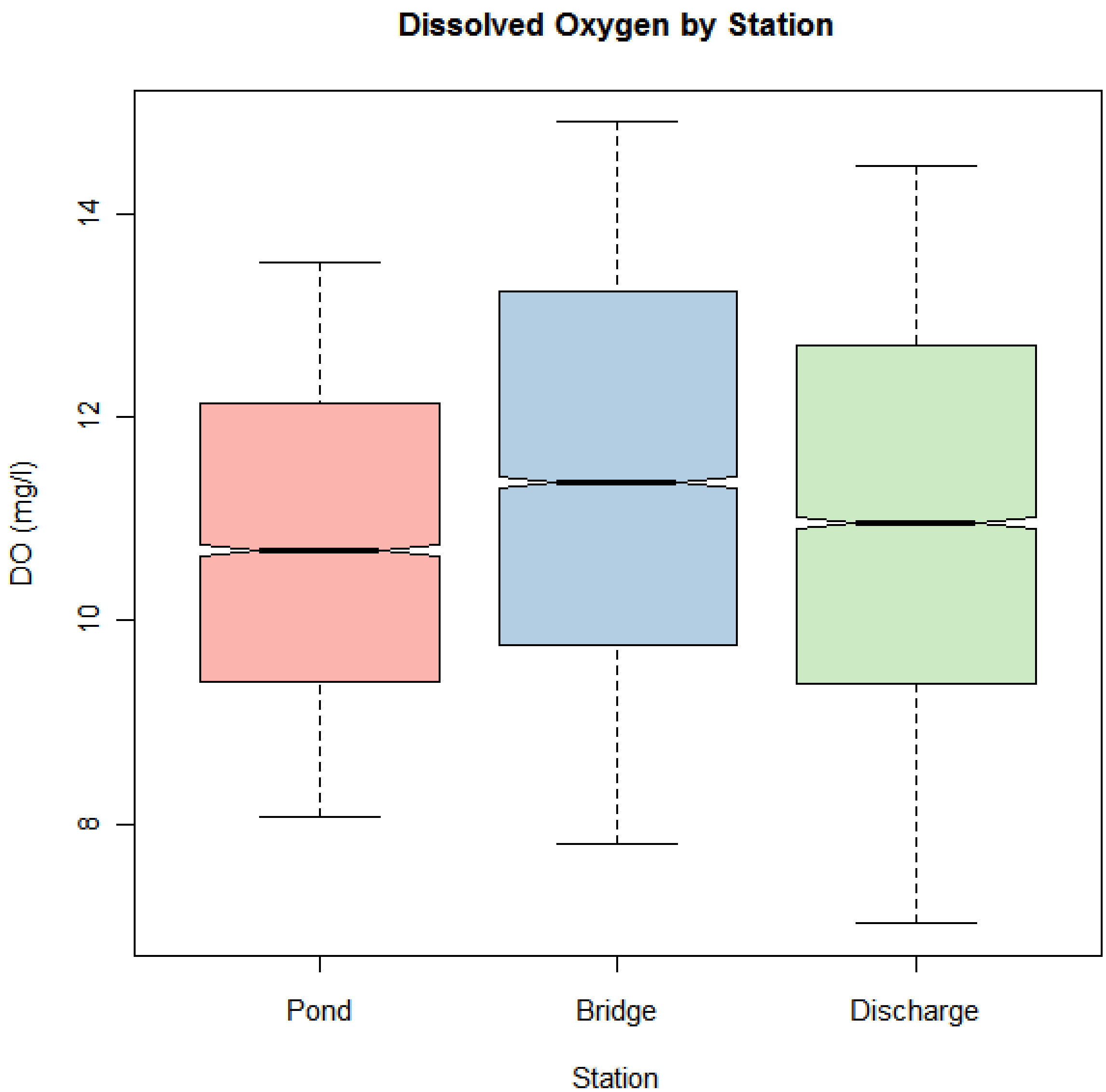


**Figure 30: Boxplots of Dissolved Oxygen for Pond, Bridge and Discharge Stations in 2010**




## Turbidity

Traditionally, Pond station experiences minimal amounts of turbidity due to the pristine locale and the absence of fast-flowing water. Most turbidity influences are wind-driven waves or errant debris carried by the sensor. Bridge and Discharge stations, however, intercept turbidity events related to heavy flowing water and silt from overland flow near construction areas.

Outlier values are common in turbidity as Figure 32 shows. Turbidity tends to be quite flashy and transient because of the fast flowing water commonly occurring during turbidity events – the particulate matter is normally flushed through the system quickly.

Notably in Figure 31, the elevated turbidity levels at Bridge and Discharge stations begin a declining trend from March until July where zero turbidity recordings are once again common until late September. Hurricane Igor, on September 21st resulted in the instability of stream which became susceptible to erosion during slight precipitation events.

**Figure 31: Turbidity at Pond, Bridge and Discharge Stations in 2010**

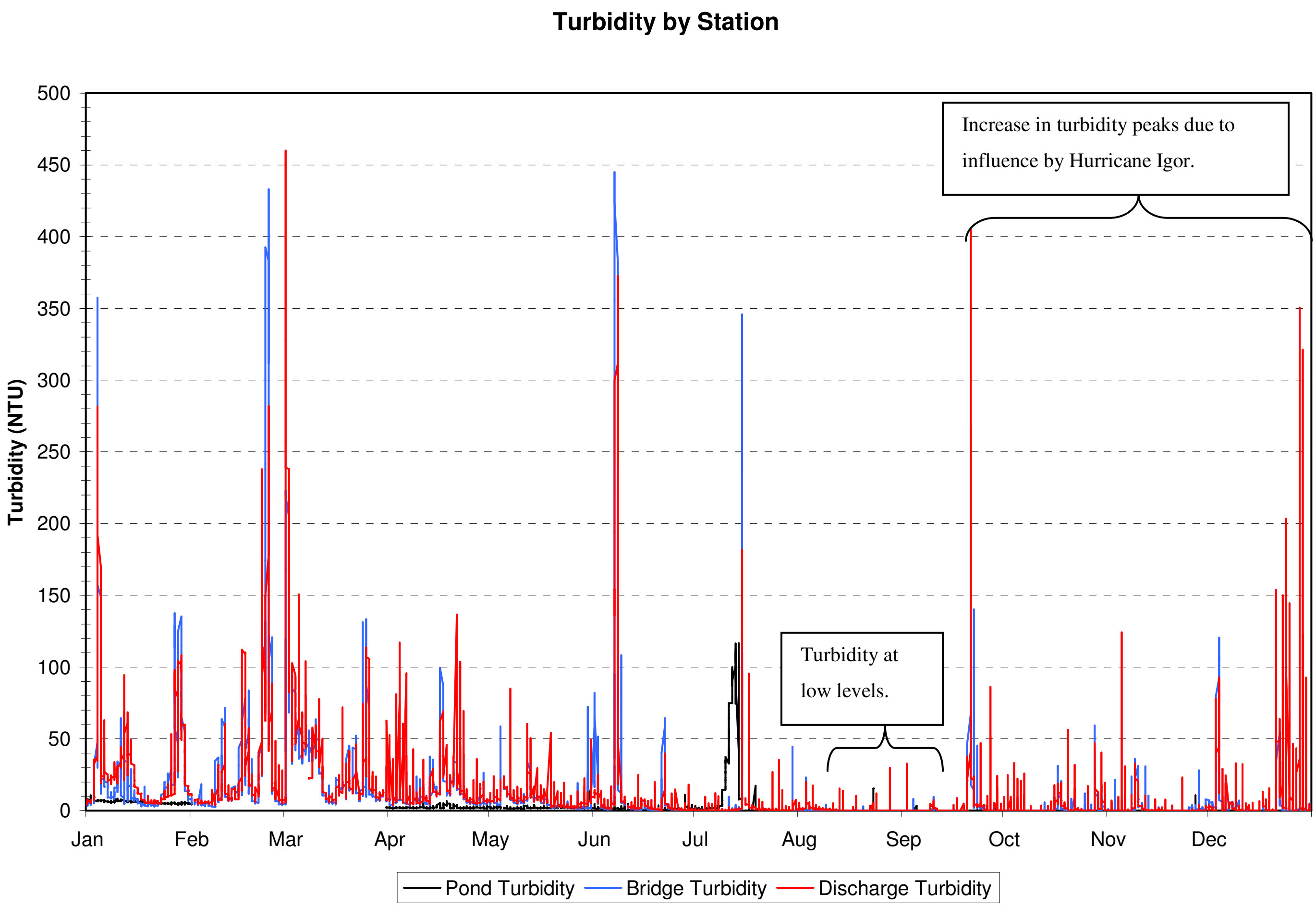
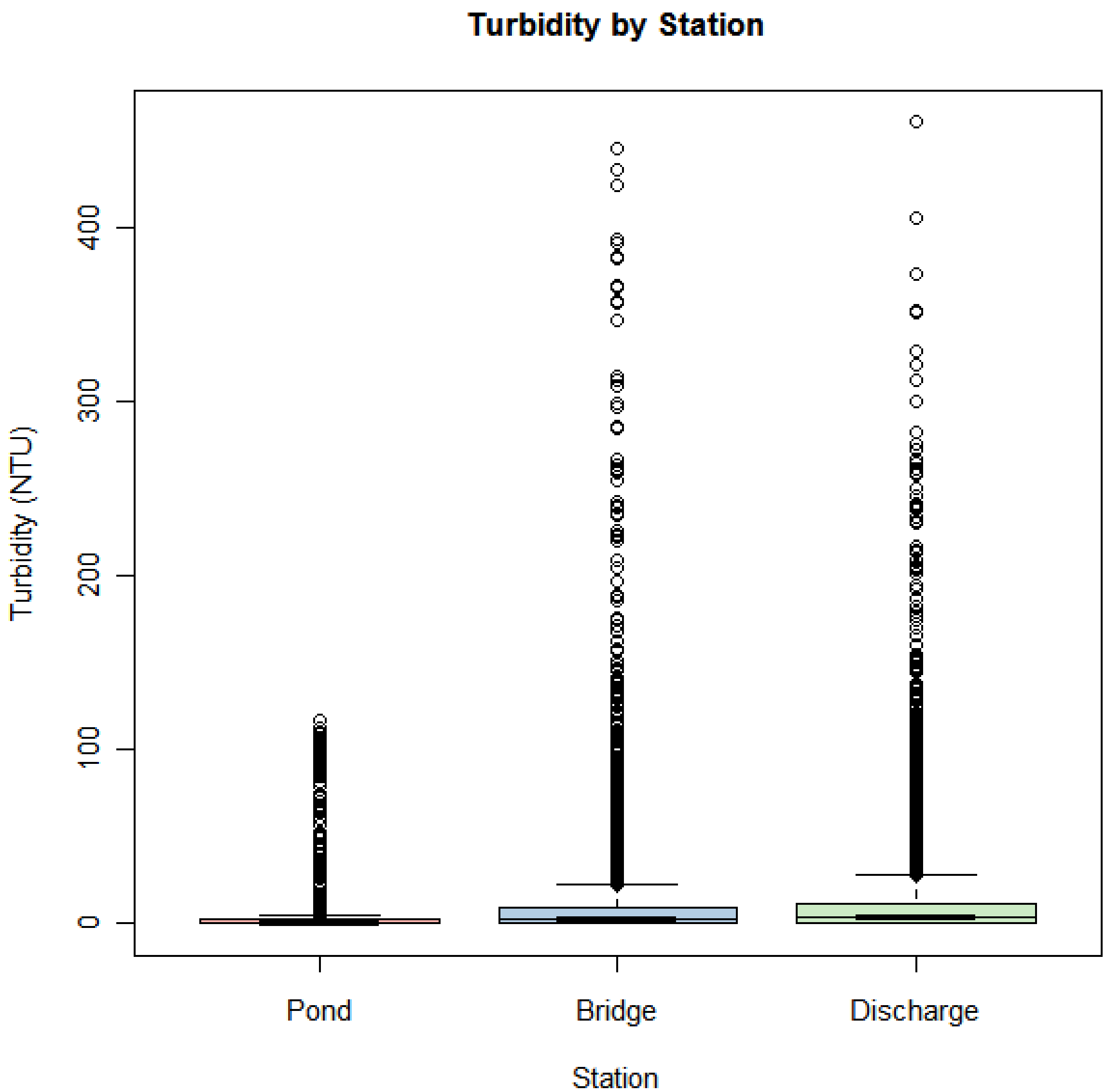


**Figure 32: Boxplots of Turbidity for Pond, Bridge and Discharge Stations in 2010**




## Conclusions

- Mid-winter ice cover precluded the deployment of water quality instrumentation at Big Pond station from February to the end of March in 2010. It is feared that the action of ice breaking up and rating in high winds could cause severe damage to equipment.
- Communications with all stations were nominal in 2010 and no major outages were observed.
- Site Specific Guidelines for pH were implemented in 2010 using the background concentration method ($5^{th}$ and $95^{th}$ percentiles) established by the CCME. In instances where pH values were found to be

outside the SSGs, no trend was found to suggests a long term deviation needing investigation. Given the method for creating the SSGs, it is assumed that 10% of annual pH values will be outside the SSGs.

- CCME Guidelines establish threshold values for dissolved oxygen based on the life stages of key organisms found in fresh waters throughout Canada. For early life stages this limit is set at 9.5 mg/l DO and 6.5 mg/l for other life stages. In the warm summer months, DO is normally below 9.5 mg/l after most organisms have passed their early life stages; at now point, however, did DO drop below 6.5 mg/l in 2010.
- Turbidity appears to have improved in and stabilized towards the end of 2010 as ground works have tailed off and construction of infrastructure and buildings has become the main activity. Many storm water control structures and settling ponds are now in place.
- An increase in conductivity from 2008 – 2010 at Bridge station and an increase over 2010 at Discharge station may indicates that silt intrusion into Rattling Brook may need attention in some cases.
- Other parameters such as temperature, pH and dissolved oxygen appear to be within seasonal variation and do not pose any cause for concern.

## Path Forward

- For the continued success of real-time monitoring in Long Harbour, DOEC is constantly striving towards improving data provided to partners. At present work is continuing on the further development of TSS as prediction through turbidity monitoring. Assuming a satisfactory level of accuracy is reached, TSS may be presented online and in near-real time.
- Advanced statistical models relating data gathered through monthly samples and real-time data are under way. Such models may allow for the prediction of non-measured parameters (such as metal ion concentration) in near-real time.
- Automated turbidity alerts have proven useful to DOEC and Vale in identifying periods where special concern is warranted regarding the level of particulate matter in Rattling Brook. These alerts will continue and continue to be refined as more information is gathered.
- Monthly and annual reports of water quality will continue to be disseminated to partners through the DOEC website.

# Appendix

**Figure 33: Mean Daily Air temperature at the Argentia Weather Station for 2008, 2009 and 2010**

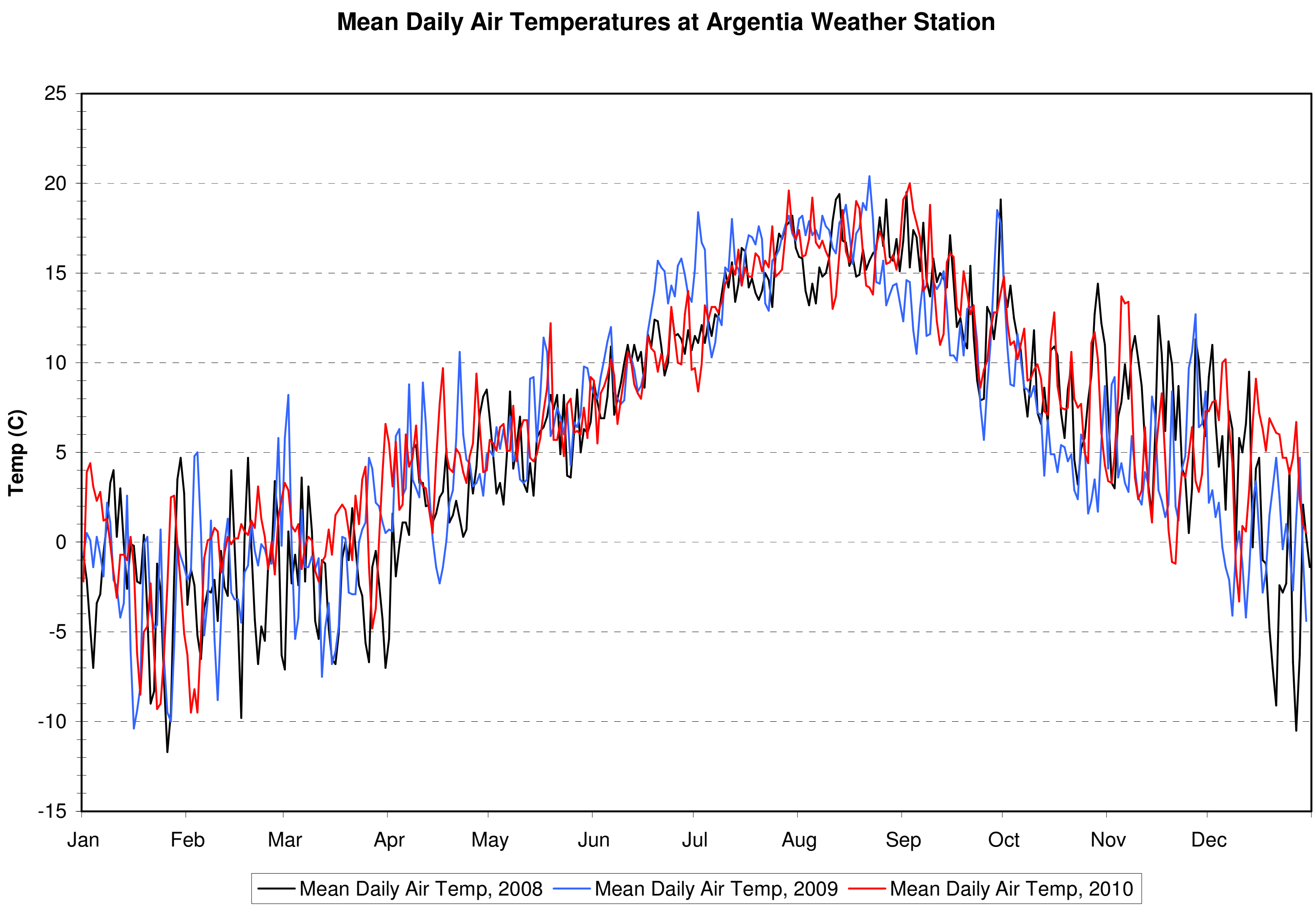


**Figure 34: Total Daily Precipitation at the Argentia Weather Station for 2008, 2009 and 2010**